Contaminated LAnd Rehabilitation Network for Environmental Technologies

CLARINET

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Final Conference

Sustainable Management of Contaminated Land

Proceedings

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Sustainable Management of Contaminated Land

Proceedings of the CLARINET Final Conference

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Foreword

A long history of environmental pollution is archived in soils and sediments. Water transfer in many contaminated sites across Europe results in unacceptable amounts of contaminants leaching into groundwater. Former industrial areas, contaminated sediments and landfills cause a number of serious problems for land-use, groundwater and terrestrial and aquatic ecosystems. A major issue for all European countries is finding solutions which reduce the costs of dealing with land contamination without compromising public health and water quality or business confidence in the benefits of land regeneration and the sustainable use of soils.

The current Conference is to be seen in context with the concerted action CLARINET – Contaminated Land Rehabilitation Network for Environmental Technologies. The project is funded by DG Research of the European Commission – and is carried out by experts from 16 European (mainly EU) countries.

The primary objective of CLARINET is to make recommendations for sound decision-making for rehabilitation of contaminated land based on current scientific knowledge. Meeting the objectives of the project requires an interdisciplinary approach by involving the affected stakeholder groups. Therefore an international network has been established including scientists from different research disciplines as well as representatives from the federal authorities and industry. The programme of the Conference also reflects the interdisciplinary approach by active involvement of these stakeholder groups.

The elaboration of a concept of "sustainable management of contaminated land" and its major elements has been main product of CLARINET. Both the concept and its elements will be discussed in the light of environmental legislation and research at national and European level. Although the results of the project were elaborated mainly by representatives from EU countries, a multi-national approach is implied that concerns above all the Accession Countries.

The issue of locally contaminated soils and groundwater is often considered a national problem. However, the scientific principles for tackling contaminated site problems are not confined to national boundaries. Therefore international co-operation and networking are called for. Moreover, in the field of legislation it is also becoming clear that the protection of the environment (protection of water resources in this case as expressed e.g. by the Water Framework Directive) is of international interest.

The current Conference aims at encouraging international co-operation in the field of contaminated land management and shall contribute to a better understanding of the different interests of various stakeholder-groups.

Martin Schamann, Harald Kasamas

1 MANAGEMENT OF CONTAMINTED LAND & GROUNDWATER – PART 1: POLICY

1.1 EUROPEAN COMMISSION'S APPROACH FOR WATER AND SOIL PROTECTION IN THE EU

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"Water is not a commercial product like any other but, rather, a heritage which must be protected …"
First sentence of the EU Water Framework Directive

Introduction

Europe's citizens are increasingly asking for a cleaner environment water, clean water for drinking and bathing, clean water in rivers, lakes and coastal waters, non-contaminated soil – as part of their environment, their local and regional heritage.

At the same time water and soil problems throughout Europe, in the North and in the South, in the East and in the West, show a quite diverse pattern: On the 'water' side pollution of our groundwaters, lakes and rivers, flood events, but also local and regional scarcity in water, and protection of our waters as a resource, be them fresh waters or marine waters. On the 'soil' side issues such as erosion and desertification, soil contamination from point sources and diffuse sources or soil sealing.

Many of these problems may have considerable impacts on the local communities and regions concerned, and depending on the situation they may be the source of the problem or its victims. To mention just two examples: declining tourism due to water pollution, or farmers depending on soil for their livelihoods.

For the EU the Treaty provides for a comprehensive remit on environmental policy encompassing water and soil, based on preventive action, rectification at source and polluter pays principle. The EU has a role in environmental policy where this can deliver added value vis-à-vis action by individual Member States.

Water Protection and Water Management

It is against a background of problems and citizens' awareness, but also knowledge and experience on solutions that the European Union has just thoroughly restructured its water policy. A lot has been achieved in the past years – as shown in recent reports by the Environment Agency [123], but more efforts will be needed in

[1] European Environment Agency: "Environment in the European Union at the turn of the century", Luxembourg 1999

[2] European Environment Agency: "Sustainable use of Europe's waters ? Part 1: State, prospect and issues", Copenhagen 2000; http://www.eea.eu.int

order to preserve and protect groundwater and surface waters as a heritage for us and our children.
The operational instrument of this new water policy is the EU Water Framework Directive. It will have the following main objectives:

- expanding the scope of water protection to all waters, groundwaters and surface waters including coastal waters;
- achieving "good status" for all waters by a set deadline of 15 years;
- water management based on river basins as the natural hydrological unit;
- "combined approach" of emission controls tackling pollution at the source, and water quality standards to be achieved for all water bodies, plus phasing out particularly hazardous substances;
- getting the prices right, to give an incentive to the wise use of water as a limited resource;
- getting the citizen involved more closely, by mandatory public participation;
- streamlining legislation.

Following adoption by the European Parliament and the Council, the Directive has come into force on 22 December 2000.

The Water Framework Directive presents a breakthrough in European Water Policy, not only as regards the scope of water protection, but also as regards its development, and, I dare say so, its forthcoming implementation.
The Commission has, right from the start, developed this new policy in an open and transparent way involving all stakeholders, water users, the scientific and research community and NGOs. Only based on a broad consultation exercise including a two-day Water Conference did the Commission come forward with its legislative proposals.

<u>Tough on objectives, flexible on tools</u>: Whilst the environmental objectives are set in an ambitious and enforceable way, the Directive offers at the same time the Directive offers sufficient flexibility as regards the measures to address the problems within the river basin, looking at regional and local circumstances and the technical and scientific facts.

<u>Management based on river basins</u>: As waters do not respect administrative or political borders, one of the Water Framework Directive’s main innovations is management by river basin. Several regions and river basins throughout Europe have served as a positive example for this approach to water management, e.g. Rhine, Labe/Elbe or recently the Danube basin.

<u>Resources protection:</u> The new water policy looks at the protection of water as a strategic and limited resource for us and our children. This is achieved along two main lines. On the one hand the binding objective for groundwater has a strong quantitative component, i.e. a long-term balance between abstraction and natural recharge. On the other hand, water pricing will be a major element to conserve adequate supplies. Whilst water pricing has got a long-standing tradition in some regions of Europe, this is not the case in others. Taking into account the principle of recovery of costs must lead to water pricing policies giving adequate incentives to use our water resources efficiently and environmentally wisely. In a more general way such considerations will also be part of the developing EU Sustainable Development Strategy.

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[3] European Environment Agency: "Sustainable water use in Europe. Part 2: Demand management, Copenhagen 2001; http://www.eea.eu.int

Further instruments: Beyond environmental legislation water protection and water management is taken into consideration and promoted by a range of instruments, and I just want to mention the EU research policy, Community funding regimes (Structural Funds and the Cohesion Fund for the Member States; new instruments for Candidate Countries) or the reform of the Common Agricultural Policy. It is evident that the Commission has a major task ahead in ensuring that the environmental requirements are fully integrated into the Regional and Agricultural Policies. This also relates to water pricing.

Soil Protection

Whilst the EU has so far not developed a soil protection policy *per se*, a range a measures contribute to soil protection:
Directives on sewage sludge and on urban waste water treatment, the Landfill Directive, the Directive on Nitrates Pollution from Agricultural Sources, as well as in the nature protection field the Habitats Directive;
The monitoring of soil condition through the Community scheme for the protection of forests against atmospheric pollution;
Further, a range of financial support measures impact on soil: the Common Agriculture Policy after Agenda 2000 including cross-compliance and rural development measures, Regional Policy including Structural and Cohesion Funds.
EU Research Programmes
A European body for discussion - the European Soil Forum (ESF), an initiative jointly launched by the Commission and some Member States.

Soil having increasingly become the focus of scientific as well as political attention[4], further action at EU level is envisaged. The 6th Environment Action Programme, currently being negotiated by the European Parliament and the Council[5], foresees a thematic strategy on soil protection. The Commission intends to develop this idea on a broad basis with all interested and involved parties, in line with a greater focus on research along the lines of the proposed new Research Framework Programme 2002-2006. To that aim, a Commission Communication on soil issues will be developed until mid-2002.

This contribution reflects the views of the author and not necessarily those of the European Commission.

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1.2 WATER & SOIL PROTECTION IN AN EU ACCESSION COUNTRY

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Abstract

The new Hungarian Governmental Decree 33/2000 (III.17.) came into force on 7th June 2000. This provision aims to harmonise the Directive 80/68/EEC, their aims are similar, but in some parts it is intended to solve more problems, than the Directive. The registration system, licensing, data reporting, preliminary investigations are determined, the competent authority is designated. The second part of the Decree contains the provisions for the remediation of the polluted sites, which is not included in the Directive. It deals with the national inventory, the provisions related to the remediation, contains the pollution limit values for both soil and groundwater the follow up monitoring, the legal consequences and imposing the fine.

Introduction

Hungary is situated in the Carpathian Basin, the surface is dominantly flat. The surficial geological formations are clastic sedimentary units, like gravel, sand, silt and clay, deposited by a dense drainage system. As a consequence, the geologic environment where we have to apply our soil and groundwater policy, and where we have to manage soil and groundwater contamination cases, is a basin structure, positioned downgradient of most of its neighbouring areas. The sandy-gravel sedimentary deposits form large aquifer units where groundwater migration can be considerable. The regional and local groundwater regime results in groundwater flow with vertical migration components. These are the basic features governing soil and groundwater sensitivity for contamination.

The groundwater is very important in Hungary, because more than 90 % of the drinking water is originated from it and several other demands are also covered from the groundwater resources. This situation is related to the hydrologic and hydro-geologic conditions of the country.

Although about 2/3 of the groundwater resources are located in vulnerable environment the quality inconvenience of the drinking water is mainly due to the naturally derived components (as arsenic, iron, manganese, ammonia).

Description

The environmental problem of polluted sites was recognised on national level more than ten years ago in Hungary. The first experience in Hungary of remediation of environmental damage was gained at former Soviet military bases. The 1991 short- and medium term action plan of the Government, which identified the tasks of surveying, assessing, and eliminating accumulated pollution – took place at abandoned Soviet barracks and training grounds after they had left Hungary - can be considered as the starting point for the National Environmental Remediation Programme. It became known that there are several other polluted sites. The privatisation process, which has been carried out for the middle of nineties, has given reinforcement for impact assessment and environmental audit of the industrial sites. The National Environmental Remediation Programme has been started due to a

Governmental Decision in 1996 with the responsibility of the Minister for environment. It covers the professional guidance of technical tasks and the remediation of polluted sites where the Government is responsible. In the Hungarian terminology the Government is responsible in cases where:

- Pollution was caused by State organisation
- The site owner is the State and the polluter cannot be made responsible
- Polluter is unknown and the site owner cannot be made responsible
- In the process of privatisation the State has taken the responsibility

The Hungarian environmental legislation is based on the Act No. LIII. (1995). On the General Regulations Concerning Environmental Protection. The detailed legislation is the new Gov. Decree 33/2000 for the protection of the groundwater - which complies with the EU requirements prescribed by the 80/68/EEC - and soil protection. It gives legal frame for the remediation process of the polluted sites as well.

The Gov. Decree provides for the procedure of remediation, which has to be based on licence of environmental authority. The public health and the water authorities take part in the procedure too.

Based on hydrogeological features, a contamination sensitivity map was created for Hungary. This map can be regarded as a thematic presentation of certain characteristics of environmental relevance. The sensitivity of certain areas to the contamination should be considered when soil or groundwater contamination issues are to be managed. The necessity of intervention and the limit values depend on the vulnerability of the site.

The system of soil and the groundwater limit values are important factors of the legislation, which are determined by the joint Ministerial Decree 10/2000 (VI.2.):

- (A) background concentration (which occurs by natural derivation)
- (Ab) demonstrated background concentration (locally investigated site specific background value)
- (B) Pollution limit value
- (Ci) intervention pollution limit value
- (D) remediation limit value of pollution
- (E) special pollution limit value

The (D) or (E) values can be determined individually by risk assessment. The implementation of a risk-based approach of contaminated land management must fit in the regional characteristics of the Basin structure. The existing risk assessment approaches are under evaluation, with an aim to adopt and compile a method, which considers not only human receptors but also the groundwater and ecological receptors as valuable resources to be protected.

It is probable that there will be no exclusive method accepted, however, a basic framework will be set forth by determining minimum requirements of a risk assessment. These minimum requirements are expected to identify sampling procedures, potential transport pathways, compliance points, exposure routes, acceptable risks for carcinogenic and toxic substances, and the level of uncertainty.

Any risk assessment is only valuable if it is accepted. Therefore the practical implementation requires such legal rules that can accept the approach, and also a good level of understanding by the regulatory agencies. The general idea and the basic elements are already incorporated in the legislation, while technical guidelines, training and seminars for the authorities are planned for the future.

Conclusion

International co-operation has great importance, the opportunity to make known the foreign experience. The research, the adaptation of innovative technologies, the use of risk assessment models etc. accelerate our preparation for EU accession, and makes basis for future common work.

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2 MANAGEMENT OF CONTAMINATED LAND & GROUNDWATER – PART 2: STRATEGY

2.1 DEALING WITH THE ENVIRONMENTAL DAMAGES FROM THE PAST IN THE CZECH REPUBLIC

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Abstract

A great problem in elimination of environmental burdens from the past in the Czech Republic is the lack of an unam biguous legislative framework, that would permit a complex solution for all legal entities. The best results were achieved in remedy of contamination connected with the process of privatisation and with stay of the former Soviet Army. Many of contaminated sites is possible to consider as brownfields. The elimination of environmental burdens from the past leads to an improvement of the environment, where preference is given especially to the elimination of actual or potential sources of contamination of the groundwater.

Introduction

Activity of the industrial enterprises during last 100 years led to contamination of soils and ground water in thousands of sites in the Czech Republic. Also army bases, especially airports, were often heavily contaminated. The most serious contaminants include petroleum hydrocarbons, chlorinated hydrocarbons, polychlorinated biphenyls, pesticides, radionuclides, heavy metals and other toxic substances.
After the 1989, the political changes enabled the clean-up programmes to be started in our country. The strategy for elimination of environmental burdens from the past in the Czech Republic is based on the principles of the environmental policy of MoE. One of the basic principles includes finding a socially acceptable level of environmental and health risk. This approach is based on the fact that the attaining of "zero risk" (e.g. absolute elimination of the contamination) is not always necessary from the standpoint of the environment and is usually associated with extremely high costs. A second important principle is based on future use of the territory (i.e. so that it is "suitable for use"). In some cases, where decontamination is technically difficult to solve or financially unacceptable, consideration can even be given to an approach in which it is necessary to modify the subsequent use of the site.
The basic principle implemented in elimination of environmental burdens arising nowadays is that the burden should be eliminated by the party that caused it (the "polluter pays principle"). One of the key difficulties lies in burdens from the past for which the responsible party no longer exists or is not capable of eliminating the burden. A great problem is the lack of an unambiguous legislative framework, that would permit a complex solution for all legal entities. The subject of environmental burdens from the past began to be broadly discussed in the Czech Republic at the beginning of 1990 in connection with the departure of the former Soviet Army and with burdens connecting with the privatisation of the state enterprises (Law No.

92/1992 Coll., in the wording of later laws, on conditions for the transfer of state property to other persons). In the former case, decontamination measures are paid from the state budget and in the latter, from the National Property Fund (NPF).
Recently MoE prepared the draft of a law about environmental burdens. The law proposal will be submitted to the Government next year and is expected to be in force in 2003.

1. Remediation of Damages Caused by the Soviet Army

The presence of the Soviet Army on the territory of the Czech Republic led to significant environmental damage. The Soviet Army used 73 variously large sites in CR. It has been found by investigations that the extent of environmental damage is significant at about 60 sites. The total amount of contaminated soil has been estimated at 1.24 mil. m^3. The main environmental damage at former military sites is contamination of the ground water. The main contaminants are petroleum hydrocarbons, chlorinated hydrocarbons, and also polychlorinated biphenyls, heavy metals and other toxic substances.
The sites with the most extensive contaminated areas and the highest risk levels include the former Hradcany airport in the former military training area of Ralsko and in the original training area of Mladá, i.e. in the vicinity of Milovice.
In 1990 - 2000, the amount provided from the state budget for study and decontamination work, including risk analysis and supervision reports, equaled approx. 1 118 mil. CZK. It is expected that it will be necessary to expend a further 320 - 370 mil. CZK by the year 2008. Total expenditures only for decontamination work on groundwater, soil and unregistered landfills alone will probably equal about 1.3 bil. CZK. This amount should be sufficient for attaining an acceptable level of environmental pollution to permit reasonable utilisation of this area. Payment for these cases comes entirely from the state budget without any contribution from the countries of the former Soviet Union.

2. Remediation of Damage in the Framework of the Privatisation

The first step that the founder of the privatised property is obliged to take on the basis of Act No. 92/1991 Coll., on the conditions for the transfer of state properly to other persons, as amended, consists in the preparation of an environmental audit for the privatised companies as part of every privatisation project submitted after Feb. 29, 1992.
First Resolutions of the Government of the Czech Republic concerning this problem, No. 455/92 and No. 123/1993, began a systematic approach in solving remedying ecological burdens caused by the state as the former owner of privatised property. Further Resolution, especially No. 810/1997 and latest No. 51/2001 have laid down new details concerning all the steps of remedying process.
On the basis of consent from the Government of CR, NPF concludes an agreement with the new owner (i.e. an Environmental Liability Agreement). According to this agreement, NPF reimburse costs incurred for remediation measures regarding soil, groundwater and building structure contamination that arose prior to the date of privatisation.
The next step consists in carrying out of a risk analysis, paid by NPF intended for remediation of environmental burdens from the past. MoE issued Methodical Directives which lay down criteria for assessing the danger of pollution of the soil and groundwater and standardise the procedure for preparing the risk analysis.
The Czech Environmental Inspection (CEI,) as the independent administrative body of MoE, on the basis of the results of risk analysis, issues a site-specific remedial order, in which the extent of the environmental burden is specified and the site clean-up standards and deadlines are delimited. In this case, this consists in measures for

remedy imposed pursuant to § 27 of Law No. 138/1973 Coll., on waters, in the wording of later regulations. Remediation measures are imposed by the Regional Inspectorates of the CEI.
The effectiveness of means expended for remediation of environmental burdens from the past is ensured by professional supervision organisations.
In the period 1991 and December 31,2000, the Government of CR approved 257 contract guarantees of NPF, in an amount of 139.233 bil. CZK; of this number 240 Environmental Liability Agreements were concluded. In period 1991 - 2000 payments were made in an amount of 9.379 bil. CZK. Remedying works finished at 17 sites, 89 cases are processing. The coking plant Karolina in Ostrava is the greatest contaminated sites (1,7 bil. CZK; 500 000 t of soil contaminated by coal tar, clean-up method - thermic desorption).

3. Register of the Past Environmental Burdens, List of Top-Priority Environmental Issues

In 1996 a database entitled the "Register of the Past Environmental Burdens" was created at MoE, the database is completed up to now. In 2000 records of 2 885 sites were stored in the central database. The database registers a total of 2 619 landfills, and also includes the register of closed landfills. The database has been installed on the MoE server and is intended for all employees of the state administration, is regularly updated by supplementing data on environmental damages and on closed landfills.
In 1999, a list of top-priority environmental issues in the individual regions was drawn up in cooperation with the regional inspectorates of CEI and the district authorities. The prepared list will be utilised by the individual areas, regional departments of MoE and especially NPF, which will use it to deal with remedying of environmental burdens from the past on the basis of the importance of the pollution. So far, decontamination has been carried out in privatised enterprises in an order corresponding in time to the privatisation procedure.

4. Brownfields

MoE, as the highest body of environmental state administration, bears responsibility in preparing and implementing state policy in the sector of brownfields. Many of contaminated sites solved at Department of Ecological Damages in the framework above mentioned processes (Privatisation, Damages Caused by the Soviet Army) is possible to consider as brownfields. But there is no unified approach based on independent law dealing with environmental burdens in CR yet. First it is necessary to create a centralised database of damaged sites, to make a system for prioritisation of these sites, to ensure financial sources and to change laws concerning urban planning. Only in this way is possible to eliminate hazards to humans health and the environment on the one hand and to reintegrate this areas into economic cycle on the other hand.

Conclusions

The remediation system of environmental damage from the past is open and continuous process, further development and improving of which depend on preparation of laws, financial sources, technological progress in remediation technologies, field sampling, data analysis and data interpretation.
Nevertheless, the elimination of environmental burdens from the past leads to an improvement of the environment, where preference is given especially to the elimination of actual or potential sources of contamination of the groundwater. In

addition, foreign investors prefer companies where the absence of environmental burdens can be unambiguously demonstrated.

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2.2 TOWARDS SUSTAINABLE REHABILITATION OF CONTAMINATED LAND IN EUROPE – THE MERIT OF NETWORKS

Harald Kasamas, Joop Vegter, Martin Schamann

Abstract

Experiences with Concerted Actions like CLARINET and its predecessor project CARACAS have shown that the close co-operation between European Member States and the European Commission are powerful tools to tackle the perceived problems with contaminated land and groundwater. Such technical-scientific collaboration networks can competently utilised the expertise and resources already available and can prepare common grounds where European-wide procedures could be applied successfully. This in turn will lessen the existing differences in the practice of dealing with land contamination in the various European countries and the resulting economical distortion of the common market.

Concerted Actions are efficient tools to share knowledge on the subject and to understand the backgrounds for diverse approaches in use in European countries and the various perceptions by different stakeholder groups. They are essential to co-ordinate multinational RTD activities, to avoid unnecessary duplication of R&D activities on a national basis and to develop jointly a broader basis for scientific peer review. These networks are important for developing the international state of the art and identifying priority research needs. The results from these international partnerships provide useful sources of information for practitioners in the field.

The Concerted Action CLARINET provides such an interdisciplinary network on the sustainable management of contaminated land in Europe. It brings together the combined knowledge of various stakeholders such as scientists, government experts, and industrial land owners from 20 European countries. The major objective is to develop a sound basis for competent decisions making on contaminated land management aspects in Europe. This paper highlights major developments and results achieved during the course of the CLARINET network. For a comprehensive overview, the reader is referred to the CLARINET Website at http://www.clarinet.at.

1 Introduction

Twenty or so years ago land contamination was usually perceived in terms of relatively rare incidents, with poorly known but possibly catastrophic consequences for human health and the environment. Several incidents attracted major media attention, e.g. Love Canal, New York State; Times Beach, Missouri; Lekkerkerk, the Netherlands. As a result politicians responded by seeking maximum risk control: pollution should be removed or contained completely.

Today land contamination is no longer perceived in terms of a few severe incidents, but rather as a widespread structural problem of varying intensity and significance. It is now widely recognised that drastic risk control, for example cleaning up all sites to background concentrations or to levels suitable for the most sensitive land use, is neither technically nor economically feasible. To give an example, in 1981 about 350 sites in the Netherlands were thought to be contaminated and possibly in need of remedial action. By 1995 the number had grown to 300,000 sites with an estimated cleanup cost of 13 billion ECU. Similar circumstances exist in most other industrialised countries. Consequently, although the need for policies to protect soil and groundwater is recognised, strategies for managing “historical” contaminated land – legacies from past industrial activities – have moved towards integrated solutions based on ***suitable for use*** concepts *(Ferguson, 1999)*

However, effective and responsible risk-based management approaches require substantial research efforts to provide a reliable scientific basis for sound decision making. Related research activities are already supported by some European countries and the European Commission. Obtained results and experiences from these activities may be very beneficial to other stakeholders. Therefore, international networks for sharing information, developing case studies, disseminating research results and identifying research priorities have been launched during the last years. These networks are essential to avoid unnecessary duplication of R&D activities and to develop a broader basis of scientific peer reviews. The results from these international initiatives provide useful sources of information for practitioners in the field *(Ferguson & Kasamas, 1999)*.
CLARINET – *The Contaminated Land Rehabilitation Network for Environmental Technologies in Europe* - offers such opportunities for contaminated land researchers and practitioners to learn about the current technologies and practices used in European countries, and also to bring their own expertise and experiences to the attention of an European audience.

2 CLARINET - Contaminated Land Rehabilitation Network for Environmental Technologies

The Concerted Action CLARINET is a network of 20 European countries, co-ordinated by the Austrian Environmental Agency and supported by the European Commission's Environment & Climate Programme. CLARINET brings together the combined knowledge of academics, government experts, consultants, industrial land owners and technology developers. It provides an interdisciplinary network on the sustainable management of contaminated land in Europe, analyses key-issues in decision-making processes and identifies priority research needs on technical, environmental and socio-economic topics. CLARINET focuses on the scientific basis of currently applied risk-based procedures in European countries, aiming to evaluate the current state of the art and to stimulate scientific collaboration on identified research needs in Europe.

3 Clarinet Objectives

The primary objective can be broken down into three activities:

(1) Analysis of key-issues in decision-making processes and identification of priority research needs for the sustainable management of contaminated land in Europe. This analysis integrates risk assessment, decision support issues and remediation aspects and takes the underlying policy frameworks and different concerns and requirements in the various European countries into account.

(2) Creation and maintenance of a network for exchange of information on available methods, technologies and policy approaches.

(3) Stimulation of international co-operation, especially for RTD, training and education networks and research infrastructures

4 Clarinet Themes & Initiatives

To yield an integrated approach within the project, seven interlinked working groups are addressing problem and solution related aspects for contaminated land management. Following themes are addressed by the CLARINET Working Groups:

- Brownfields Redevelopment
- Impacts of Contaminated Land on Water Resources

- Risk Management and Decision Support
- Remediation Technologies and Techniques
- Human Health Aspects
- Ecological Aspects related to Land Reuse
- Collaboration of R&D Programs in Europe

Analysis of strategic and technical aspects have been performed on these issues within the respective working groups. Based on the identified state-of-the-art in these areas, integrative concepts and recommendations for tackling contaminated land problems have been investigated, taking country specific requirements and circumstances (such as geographical, social, economical, political aspects) into consideration.

Furthermore, priority research needs have been identified, and multinational R&D projects between European countries have been initiated to support their realisation. For example, the Dutch Environment Ministry (VROM) launched the international R&D co-operation BARGE, which is addressing research on "*Human Bioavailability of Contaminants in Ingested Soil*".

One of the CLARINET Working Group stimulates collaboration between various R&D Programme planners in Europe to enable effective co-ordination of available resources and research facilities in Europe. A strategic analysis of EU- and national R&D Programmes relevant for contaminated land have been performed and published. One outcome of this analysis are recommendations to strengthen the European research area and infrastructure with regard to a future EU Framework Programme.

5 Sustainable Contaminated Land Management - A Risk Based Land Management Approach

Besides the individual themes covered in the CLARINET Working Groups, a broader concept on sustainable contaminated land management has been developed within CLARINET *(Risk Based Land Management)*. The need for such concept has been regarded necessary to organise the decision-making process for assessment and solutions of contaminated land problems in general. This concept is based on comprehensive inventories performed in the CLARINET participating countries. These inventories have been published with following documents (available for download on the CLARINET Website *http://www.clarinet.at*):

- *Problem/Solution Catalogue*, which summarises contaminated land related problems perceived by various stakeholders and currently available ways to deal with those.
- *RTD Catalogue*, which combines identified research needs for improved problem solution strategies; and the related RTD themes currently covered by various RTD programmes.
- *Conceptual Analysis*, which "maps" the key-issues for decision making on contaminated land management.

The risk-based land management concept stresses the importance of integrative sustainable solutions, which are needed to restore the usability and economic value of the land. These solutions can be characterised by three elements: (1) risk reduction, (2) protection of the environment and (3) reduction of aftercare. The first two issues describe the environmental goals in relation to land uses and functions and soil- and groundwater protection, including the spatial planning aspects. The third describes the way these goals should be achieved.

The risk-based land management concept is the overall outcome from the CLARINET project beside the individual Working Group results. This conceptual framework for sustainable management of contaminated land is considered necessary to organise this decision-making process.

6 Information Sources

6.1 Clarinet Website http://www.clarinet.at

This website aims to provide actual and comprehensive information for all parties concerned with contaminated land management in Europe. The website offers relevant information on various aspects such as EC 5th Framework and national RTD Programmes, Policy Frameworks in 20 European countries, other international networks on contaminated land, and many more. A Web-library offers key-papers for download, and a comprehensive collection of hyperlinks refers to relevant web sources in all European countries.

6.2 Clarinet publications

Recently, first results developed in the CLARINET network have been published with various key-note papers in a special issue of the scientific journal "Land Contamination and Reclamation" (see references). This special publication highlights recent activities of CLARINET and the progress that is being made towards the establishment of better risk-based land management protocols and practices in the EU. It provides an overview of current research programmes including the current call for EU research under Framework 5, and identifies commonly perceived research needs among stakeholders in European countries. All articles are available for download at the CLARINET Website http://www.clarinet.at

7 Conclusion

In recent years we have made great strides in Europe in forging a common understanding of the problems left by our industrial heritage. It is now recognised that the emerging disciplines of environmental risk assessment and management are vital in helping us tackle the contaminated land problem. It is a common view that risk based approaches are vital to allow governments and industry to deal with contaminated land *(Ferguson et al, 1998).*

However, as in any science-based endeavour, there are numerous areas where additional research and technology development would significantly improve and advance the current use of Risk Assessment and Risk Management. Currently, contaminated land management is underpinned largely by scientific research done for other purposes. Further development and integration of these scientific building blocks is of the utmost importance. In a fully integrated approach, choices of toxicological endpoints must have consequences for the design of sampling schemes and exposure models, and vice versa. Uncertainties at each stage in the assessment should be recognised and may lead to the use of probabilistic or other techniques for dealing with uncertainty. Decision-support tools may provide guidance for risk managers to help balance reduction of uncertainties against the costs of additional investigation. Integrated risk assessment procedures have yet to be fully developed.

However, only the close co-operation between European Member States and with the European Commission will provide the needed tools to tackle these challenges towards a sustainable management for contaminated land and water resources in Europe.

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2.3 INDUSTRY'S PERCEPTION OF RISK BASED LAND MANAGEMENT

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Abstract

Sustainability applied to Contaminated Land Management does require that the economical aspects have equal weight than environmental and social aspects. Within the clear distinction of roles among different stakeholders NICOLE, Network for Industrially Contaminated Land in Europe, from its start had the mission to develop and promote the responsible (risk based) management of contaminated industrial land, creating a commonly accepted cost effective approach, based on the "fitness for use" concepts.
Risk Based Land Management is considered by Industry and most of EU member states as the best available strategy for dealing with the problems posed by land contamination allowing decision makers to allocate scarce resources for proportionate and equitable environmental risk reduction. However, Risk Assessment is not yet commonly accepted and applied and there is a gap in knowledge transfer, both in terms of methodology as well as technologies to substantially progress towards RBLM at local level.
NICOLE remains committed to strengthen links with other relevant networks, with the trust that the optimum solution will come from the process of open dialogue with all the stakeholders involved.

Introduction

NICOLE was born on February 1996 as partially EU-funded Concerted Action in the frame of the ENVIRONMENT&CLIMATE programme. Since 1.2.1999 NICOLE is sustained by its members.

Companies, looking at the contaminated land issue, became aware that:

- there was insufficient depth of knowledge and understanding of the science and technological aspects of such problem on the one hand and limited capabilities and resources on the other hand.
- unjustified fear was the driver for first national legislation that were proposed without a rational/scientific background, often resulting in an overstringent requirements and excessive clean-up effort and costs, compared to the environmental benefits achieved.
- only a multidisciplinary approach could be envisaged successful, given the problem magnitude and complexity, tackling all the different aspects, technical, financial, social as well as legal.
- furthermore it was clear that, due to diversities among MS, with regard soil characteristics, likely exposure, social/health awareness, environmental policies and industrial development, the solution would have required the definition of general, widely applicable and scientifically underpinned criteria on which the whatever chosen approach should have been based.
- co-operation and pro-active discussion with regulators was also seen as extremely important, given the envisaged huge amount of financial resources and time span needed for the solution to be compatible with free-market based industrial activity.

Aim of Industry was (and still is) to manage contaminated industrial site responsibly, achieving a broad consensus among all stakeholders on a cost-effective, eco-efficient approach.

Pursuing this goal through a constructive dialogue, networking was identified as the appropriate tool and NICOLE was initiated. Three specific groups are the basis of the NICOLE structure, representing respectively the Problem Owners, the Service Providers and the Academic.
The network is managed by a Steering Group in which all groups and the secretariat are represented (the Problem Owners elect the chairman) and where CLARINET has also a seat.

Nicole Approach to RBLM

The network organises workshops that look at different aspects of the multi-faced problem, with the aim of understanding current knowledge and identifying areas in need of user-relevant research.
Indeed the proactive participation of the academic world has been one of the outstanding achievements of NICOLE. The academics have a representative in the steering group to secure an effective exchange of information and co-operation
Another significant area of progress for NICOLE has been the development of the relationship with its sister Concerted Action, CARACAS/CLARINET, because the two networks share a common goal of providing a vision and identifying the means whereby risk assessment and management approaches can be applied effectively to ensure the safe use of contaminated land.

The two networks produced a Joint Statement on research needs on October 1997 which represented a broad consensus of opinion and was used to guide the orientation of research on contaminated land to be addressed during the Fifth Framework Programme. In a later joint document “Better Decision Making Now”, Risk Assessment and Risk Management are recognised as methodologies already sufficiently well developed to provide tools for allowing decision makers to allocate scarce resources for proportionate and equitable environmental risk reduction.

The key messages from NICOLE and CLARINET have spread significantly. Indeed Governments and Industry have recognised that excessive land clean-up can be as detrimental to environment as the original contamination.
It is also widely recognised that Sustainability applied to Contaminated Land Management does require that the economic aspects have equal weight with environmental and social aspects and, within the clear distinction of roles among different stakeholders, Industry contribution is focused on optimal usage of resources, seeking to achieve the desired environmental benefits at the lowest possible cost.

In other words, while risk management and sustainable development are the two key decision making criteria for contaminated land management and should be explicitly considered in all remediation decision making, Risk Based Land Management is considered by Industry and most of EU member states as the best available strategy for dealing with the problems posed by land contamination (NICOLE workshop, Helsinki, May 2000).
RBLM is systematic, objective and provides a consistent basis for dealing with uncertainties, making decisions and convincing interested parties that appropriate action is being taken. However, early and effective communication with all the legitimate stakeholders is recommended to ensure the earliest and widest acceptability of any decision reached.

In this context, as each site has its own specific conditions and soil characteristics, the definition of European wide soil quality criteria appears unrealistic and would cause great concern to site owners. It is therefore opinion of NICOLE that no single rigid set of legal norms, but rather that general, widely applicable, scientifically underpinned criteria are needed: Site Specific Risk Assessment and Fit-For-Purpose are the two pillars proposed for RBLM as eco-efficient/cost-effective approach.

In NICOLE experience, the costs of remedial action based on fixed soil quality criteria, when compared with Risk Assessment, show that RA brings about very significant cost savings (even an order of magnitude); also the final cost is a function of final proposed land use (fitness-for-purpose).
Given the huge number of sites believed to be contaminated, it is of vital importance to the whole of society (not only of site owners) to effectively manage human and financial resources by discriminating between "perceived" and "actual" risk to pursue environmental and social benefits and maintaining economic growth.

The Way Forward

Despite remarkable progress can be recorded, since most industries and many Member States have adopted as the necessary foundation for success in the area of risk assessment and fitness-for-use concepts, the goals of NICOLE have not been fully accomplished. While the maturing co-operation of NICOLE and CARACAS/CLARINET has played a very important role and has been an outstanding example of co-operation between Industry and Regulators, the process is not finished, as not all the information needed to allow the smooth implementation of the aforementioned principles, and the remediation technologies that support them, are in place throughout the EU.

Daily experience shows that Risk Assessment is not commonly accepted and applied. Misunderstandings and prejudices (sometimes not only among local authorities and the general public, but even among industry representatives and consultants) still prevent the proper implementation of RBLM that, conversely, is well agreed upon by experts at European level. This situation doesn't help also the intensive use of new, more cost-effective techniques (i.e. biormediation and Monitored Natural Attenuation), that rely on the definition of clean-up targets based on Risk Assessment, with the result that "dig&dump" and "pump&treat" are still the most commonly used remediation technologies, although not considered "sustainable".

NICOLE and CLARINET have identified such a gap in knowledge transfer, both in terms of methodology as well as technologies, as the main hurdle to substantial progress towards establishing RBLM at the local level.

To fulfil this need, ANCORE, the recently formed network of academics, NICOLE and CLARINET submitted a proposal at the last call of 5FP (COLAGE, concerted action for the sustainable management of **Co**ntaminated **La**nd and **G**roundwater in **E**urope), with the objectives of transferring innovative ideas and technologies into practice, defining on one hand all the technical and management aspects and on the other hand developing an information tool by which easy access would be ensured to all essential information for decision making related to "Sustainable Land Management" based on RBLM.
The proposal failed, but, encouraged by the overall positive evaluation on the scope of the new CA, the three networks are willing to join their effort for a new, better prepared proposal.

NICOLE proposes also to hold jointly with CLARINET and ANCORE a European conference on RBLM, likely in an east-European country, to revitalise the concept and bring also RBLM to the Accession Countries.

Conclusion

NICOLE remains committed to disseminating knowledge, and helping to promote a European level playing field for eco-efficient, economically viable and scientifically supported, risk-based management to address contaminated soil and groundwater concerns, seeking to strengthen links with other relevant networks, being confident that the optimum solution will come from the process of open dialogue with all the stakeholders involved.

2.4 SUSTAINABLE CONTAMINATED LAND MANAGEMENT: A CONTRIBUTION FROM THE CLARINET NETWORK

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Summary

The concept of sustainable contaminated land management originated in the CLARINET concerted action, to streamline discussions, analyses and recommendations about research and technology development needs in relation with contaminated land policies. As a result of these discussions the concept evolved into a general vision on developing contaminated land policies in EU countries. The common ground in these policies is increasing with their stronger interaction with spatial planning and water protection and their longer time perspective of sustainable environmental management. Current contaminated land approaches focus on sustainable solutions, which will restore the usability and economic value of the land. These solutions can be characterised by three elements:

1] Suitability For Use

This is achieved by reducing human health risks and ecological risks as necessary to permit the safe (re)use of the land. It is focussed on quality requirements of the land for uses and functions

2] Protection of the Environment

For example preventing further spreading of pollution by surface water and groundwater. Environmental protection of soils as a resource may also lead to policies favouring redevelopment of brownfields over greenfields.

3] Reduction of Aftercare

Sustainable solutions minimise the burden of aftercare. Endless pump and treat solutions or containment walls that require control and maintenance forever may be less desirable in view of the amount of aftercare required.

Sustainable management of contaminated land is a. ***"Risk Based Land Management"*** approach, which provides a framework for the integration of two assessments:

- **The timetable for remediation:**

  Priority setting based on current risks or society's needs to change the use of contaminated land

- **The design of the solution:**

  The best strategy to meet all requirements in a sustainable way, including environmental side effects, available space and facilities, local perceptions and other issues.

The three building blocks of the concept: ***Risk***, ***Land*** and ***Management*** are defined as follows:

1 **"*Risk*"**[6] describes the adverse environmental effects of contaminants (human health, ecosystem health, impact on aquatic environment and water resources and the socio-economic consequences of poor soil and groundwater quality).

2 **"*Land*"** will be assumed to be a bounded area. The area could be a single industrial site, or it could be a region such as municipality. "*Land*" as such is managed (see below). The manager of land, for example, may be the owner or user of an industrial site or a municipal authority. The area involved may be large, possibly involving a number of current or planned land uses.

3 **"*Management*"** is a set of activities involving decisions about assessment, clean up, landuse restrictions and spatial planning in order to define the best solution strategy.

The risk based land manager has to address the following requirements in order to assure the sustainability of the solution for a contaminated land problem:

- Risk reduction requirements
- Land use related requirements
- Spatial planning requirements
- Management requirements

Risk reduction

Risk is generally considered as the result of a process where some potential hazard (a toxic substance or other agent) could lead to an adverse effect in the "receptor" (people, animals and plants, ecosystem processes, water resources and buildings). For this process to operate there must be a connection (*a pathway*) between the potential hazard (*the source*) and target for protection (*the receptor*). So theoretically risk reduction may be achieved by removing the source, breaking the pathway and/or by removing the receptors.

Landuse

Different land uses have different needs. For example, some landuses require direct access to the soil, preventing the use of containment measures like capping with concrete or asphalt. Others may require the preparation of the site for geotechnical purposes, e.g. to support foundations

Spatial planning

Whether land use will be allowed to change may be incorporated in spatial planning, which may then contain specific requirements for the number of potential uses the site should be treated for. Spatial planning should also address the subsoil, especially in view of groundwater and surface water. If a landuse change is considered, the consequences for the geohydrology and the behaviour of contaminants that may be present must be properly assessed.

Management

In addition to the requirements mentioned above there might be other important management issues like funding mechanisms and communication with stakeholders and the general public which may affect the choice of certain solutions over others.

[1] Clarinet: Contaminated Land Rahabilitation Network for Environmental Technologies. EU DG research concerted Action. Secretariat email: Kasamas@Caracas.at

[2] The definition of risk used in this document is a general and policy oriented umbrella term for the actual and potential adverse effects of contaminated land. A formal probabilistic definition of risk is "the probability that a given adverse effect will occur". This definition may be applied to some human health effects of contaminated land, but other effects are not probabilities, they are actually occurring. In that case the term 'damage' would be more appropriate.

The manager will also have to deal with "values" which can hardly be expressed in terms of risk or utilitarian concepts like landuse of function. The conservation of pristine underground environment, and geological and archaeological values are examples of this. Moreover, legal constraints may prohibit some treatment and risk management solutions. There is also the question, how the decision making process is organised. Will it be a dynamic and open decision making process, involving all interest groups or can a standard flow chart protocol or mandatory decision support system be applied by a single decision-maker?

Concluding Remarks

In practice, optimal solutions are likely to involve a mixture of approaches. An interesting possibility is to combine a fast acting temporary measure with a longer term extensive treatment to provide an optimal balance of risk management, maximising wider environmental merit and limiting costs. Moreover, the soil itself has some interesting characteristics, which may help in reducing the risk. Soil has a natural capacity to act as a barrier, which can be used in containment approaches and it has a natural capacity to biodegrade substances. If these natural capacities can be used the costs of solutions will decrease. The use of the natural capacities of soils in remediation or contaminated land management solutions need to be further explored both from a scientific and a regulatory point of view, in order to meet the general sustainability requirements of soil protection.

2.5 CONTAMINATED LAND – WHO PAYS THE BILL? ASPECTS OF LIABILITY

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Abstract

One of the main elements to secure environmental protection is the polluter-pays-principle. This principle intends to burden the polluters, to burden those, who were able to prevent the pollution, those supposed having the benefit.
The polluter-pays-principle is usually applied to serious contamination leading to damages or serious threats to human health or to the environment.

Experience shows that people do not only disdain land with serious contamination but also land, which is slightly contaminated or which is only suspected of contamination, and even contaminated land, where remedial actions were applied.

In order to enhance attraction of used land it will be advantageous
- to release future land owners from liability for past pollution and
- to make them liable only for future soil degradation.

3 PROTECTION OF EUROPEAN WATER RESOURCES

3.1 THE EUROPEAN WATER FRAMEWORK DIRECTIVE WITH RAGARD TO CONTAMINATED LAND MANAGEMENT

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Abstract

The EU Water Framework Directive has as its primary goal the good ecological status of rivers. It introduces integrated water management on the catchment scale and requires the production of, and public consultation on, statutory River Basin District management plans. Land-use planning on a catchment wide scale will need to consider and deal with all the influences on river water quality. This will include the quality of soil and groundwater where these are historically polluted and hydraulically connected to surface water. Thus the Directive may well provide a legislative driver for the remediation of contaminated land particularly in industrialised urban areas.

Introduction

The Water Framework Directive (WFD), having been under discussion for some years, was finally agreed in June 2000 and published in the ECJ at the end of the year. It is designed to prevent further deterioration, and to protect and enhance the quality and quantity, of aquatic ecosystems. Its key objectives include:

- the focusing of environmental water policy on water as it flows naturally through river basins towards the sea;
- consideration of both surface and groundwater, taking into account the natural qualitative and quantitative interactions between them;
- the objective of achieving good status of all waters within 15 years, in particular the good ecological status of rivers and;
- the designation of “protected areas” with special requirements.

The WFD is a modern and integrated Directive that encompasses water quality, quantity and ecological issues. From the answers to the questionnaire distributed as part of the Working Group 3 exercise, it is clear that those countries that were more closely involved with its development are those most clearly aware of its, potentially very broad, implications for land-use planning and management. Some have already developed legislation that mirrors the Directive (e.g. Italy). Others are still considering the content. Uniquely, the Commission and Member States are attempting to ensure that a common approach to implementation is taken across Europe. Member States Water Directors have agreed a strategic document establishing a common strategy for the implementation of the WFD. The aim of this strategic document is to allow, as far as possible, a coherent and harmonious implementation of the Directive. Most of the challenges and difficulties arising will inevitably be common to all Member States and, as many of the European river basins are shared, crossing administrative and territorial borders, a common understanding and approach is crucial to its successful and effective implementation.

Requirements of the Water Framework Directive

The overriding objective to achieve "Good Status" for both surface water and groundwater. It applies to all waters; inland surface waters, groundwaters, transitional waters and coastal waters. Improvements must be achieved through River Basin Management Planning for which the following should be undertaken:

- The characterisation of River Basins
- An analysis of pressures on the catchment
- Environmental monitoring
- Statutory River Basin Management Plans drawn up and consulted on through a public participation process
- Programme of measures produced to ensure that the good status will be achieved by the due date.

Timetable

- Define basins, appoint Competent authorities (2003)
- Analyse basin, review human impact (2004)
- Commence Monitoring Programme(2006)
- State Issues and Objectives (2007)
- Derive measures, consult on draft plan (2008)
- Plan enacted (2009 - 2012)
- Plan reviewed (2013 - 2015)

Understanding the Pressures

The requirements for the identification of significant human pressures on the river basin district are set out in Article 5 (and Annex II) of the WFD. They form part of the wider analysis of the river basin district, comprising an analysis of its characteristics and a review of the impact of human activity on the status of both surface waters and groundwater.

This analysis must be completed within four years of the entry into force of the Directive, with a review, and if necessary an update within the following 9 years. The table below outlines the specific requirements for the pressures to be reviewed, as required by Annex II.

3.1.1.1.1.1 SURFACE WATERS	*3.1.1.1.1.2 GROUND WATERS*
Identification of pressures: collect and maintain information on the type and magnitude of significant anthropological pressures. *Point source pollution* *Diffuse source pollution* *Water abstraction* water flow regulation morphological alterations other anthropological impacts *land use patterns*	Initial characterisation to identify pressures; *point source pollution* *diffuse source pollution* *water abstraction* artificial recharge To use *land use patterns*, discharge and abstraction data
Further characterisation where relevant	Further characterisation to review; - the impact of human activity on groundwaters - the impact of changes in groundwater levels - the impact of pollution on groundwater quality

N.B. anthropological pressures that are common to both surface and ground waters are italicised

Annex II of the WFD lists the main types of "pressure" which Member States are required to identify within a River Basin District (RBD), for example point source pollution, diffuse pollution, abstractions, morphological alterations etc. For some of the different pressure types Annex II also provides some further categorisation, e.g. urban, industrial, agricultural.

However, in order for there to be fully effective implementation of the WFD, there is a need for a more detailed breakdown of the categories of the different types of pressure. This would enable a more effective analysis of the likely impact of the various pressures on water status, the development of a better targeted environmental monitoring programme, and ultimately a more effective programme of measures within the River Basin Management Plan.

Sources of Information on Pressures

The timetable within the WFD for carrying out the analysis of significant pressures is challenging and in order for Member States to be able to complete analysis on time it will be necessary to maximise the use of existing information on pressures, supplementing this with newly gathered information where necessary.

Each Member State will have differing types, sources, and amounts of information on pressures. However, it is possible to identify a number of broad categories of sources of information on pressures which will be common to all Member States, and which will potentially provide a useful structure with which to attempt to assemble the necessary information by the WFD deadline.

State of the Environment Information – many Member States produce "state of the environment" type reports, often at the national, regional and local levels. In most instances such reports will contain a wide variety of information on pressures which could be utilised in WFD implementation.

National Classification Schemes – most Member States operate one, or more, classification schemes for several of the water body types covered by the WFD. In seeking to use these schemes for management purposes Member States often collate information on why a particular stretch of water is of a certain quality/status, or why a particular objective for that stretch has not been met. This sort of information inevitably results in information on pressures on the water body being collated and categorised, which in turn will be useful in WFD implementation.

Inventories Required by National Information – most Member States national legislation requires the prior authorisation of a number of activities, such as abstractions, discharges to water, large industrial sites, contaminated land etc. Often the relevant legislation will require the licensing authority to maintain a register or inventory of the authorisations that it has granted.

Operational information – in addition to information on pressures which is available as a result of EU or national requirements Member States will usually have a variety of information on pressures which has been derived for mainly operational reasons. Examples in this area include might include information on episodic "pollution incidents" which required an operational response by the relevant authorities. Analysis of the causes of such events can provide detailed information on pressures within a river basin.

Integrated Thinking

The WFD is an integrated Directive. It challenges us to think across traditional disciplinary and legislative boundaries. A conceptual model of the river basin catchment will be essential. Do we know enough about "how rivers work" and what drives their ecology? It may be that for some situations the pressures that we think are the most important are not, because of the lack of our basic understanding of the connection between land/soil, groundwater and the river. In some urban areas therefore, where the groundwater provides the majority of the base flow to the river, it may be that the legacy of land contamination leaching into the underlying groundwater is the primary factor influencing river water quality. In other situations it may be that the pollution legacy is preserved within the river sediments and it is this which is affecting the whole surface water ecosystem and not diffuse run off or groundwater inflow.

Whatever the reasons it will mean that hydrogeologists, ecologists, chemists, hydrogeologists and other disciplines will need to work with each other in a way that many may find difficult at first. It will also mean that for some areas the impact of contaminated land may well be the critical driver for the measures to achieve the objectives demanded by the WFD. A classic example is the problems facing the River Mulde in the Bitterfeld area north of Leipzig, which formed the subject of the

Conclusions

When asked in the Working Group 3 questionnaire, most countries considered that the Directive will have some influence over their contaminated land remediation programmes, but were uncertain how big this would be. As outlined above this influence will be largely in relation to the interaction between land, groundwater and surface waters. It thus requires an understanding of the geochemical and pollutant fluxes that perhaps does not exist at present for most river catchment systems.

The Directive is likely to be most influential in urban catchments. As the impact of point source discharges on surface water quality diminishes due to action by regulatory bodies, the problems of diffuse pollution will come more to the fore. Further improvements in river water quality and the achievement of ecological quality objectives will only come about if the diffuse impacts can be identified, quantified and prioritised for action. This will require local authorities and regulatory bodies to understand the influence of historically contaminated land within urban areas on the underlying groundwater, and the influence of groundwater discharges on river systems. Where the latter is significant, particularly at times of low flow when surface run-off is low, then the requirement for river quality improvement will need to relate back to the land and the associated groundwater. Hence for those countries with large industrialised urban areas the Water Framework Directive may well be a significant driver for remediation.

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3.2 COMPARISON OF CURRENT WATER PROTECTION STRATEGIES UND OUTLOOK ON FUTURE DEVELOPEMENTS

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Abstract

European countries are facing significant contamination of groundwater resources caused by former industrial activities. Nevertheless, European countries have different legislative and technical approaches to the problems of groundwater protection and land contamination. Some of these different approaches are based on differences in legislation; some are based on the differing local perspectives on the importance of groundwater. Different regulatory approaches (technical and procedural) between water resources and contaminated land as well as different points of compliance for both protection & remediation of groundwater resources (at the water table, the site boundary or the receptor) in the European countries have been identified as the main obstacles hindering discussion and further development of water protection issues with regard to contaminated land across national borders.

Keywords: Contaminated Land, Groundwater, Pollution, Remediation, Natural Attenuation, Regulation, Europe

Introduction

Although technical specialists (such as hydrogeologists, hydrologists and soil scientists) speak a common language and share a common understanding of the science of the subsurface environment, European countries have different legislative and procedural approaches to the problems of groundwater protection and remediation of groundwater contamination. Some of these are based on the differences in legislation in different countries, some on the differing local perspectives on the importance of groundwater; some consider groundwater and soil together - in either protective or remedial measures, others consider them separately. These differences can hinder discussion in international fora as participants may have different concepts about the issues and therefore it can often be difficult to come to any consensus because of this lack of understanding. The Working Group 3 of CLARINET (Contaminated Land and its impact on Water Resources) therefore set out to try and get a little more common understanding of each others issues by seeing how much difference there really is, and how much commonality. At the same time we wanted to tease out the really important issues. The work builds on a study carried out for the Danish Environmental Protection Agency in preparation for the 4th meeting of the Ad Hoc International Working Group on Contaminated Land in Copenhagen (June 1999).

Questionnaires were sent to all CLARINET participants about many aspects of water resources management, groundwater protection and remediation. We were interested in understanding the main reasons behind any differences in the various countries' approaches. The use of a case study approach to bring out the details in a more practical way was considered but time and resources were against us producing anything of detail. We were also aware of the ConSoil 2000 Case Study[7] that covered in some part the legislative background and the groundwater issues. So a very limited conceptual model (Figure 1) was used to bring out some differences between where we establish the receptor and compliance point when protecting groundwater from pollution and remediating it once it has been polluted.

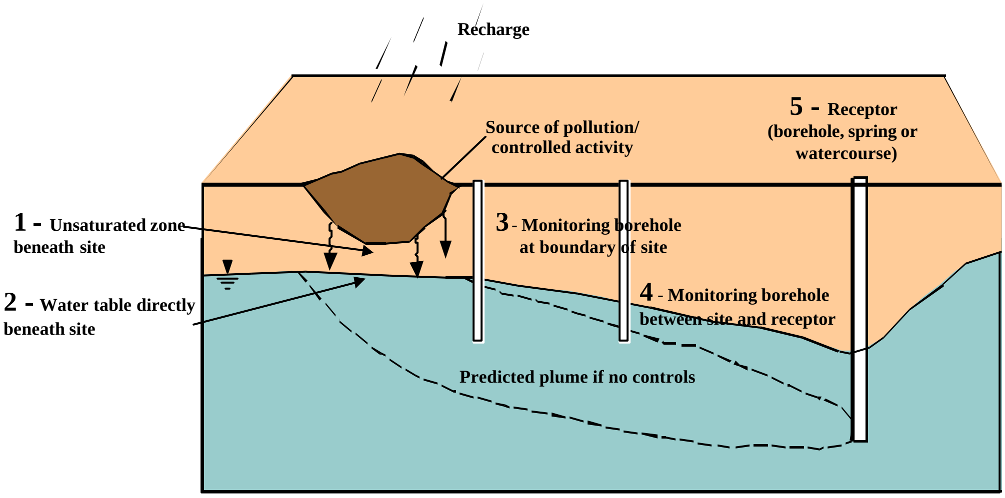

Figure 1 Conceptual cross-section through a site with a variety of potential compliance points for the protection of groundwater, and the setting of remedial targets.

Technical and Procedural Differences of Approach between Water Resources and Contaminated Land

Most countries tend to have legislation that has developed separately in relation to the management of water resources and the protection/remediation of contaminated land. Water legislation invariably predates that on contaminated land and often the requirements of the former drive actions on the latter, particularly with regard to targets (e.g. Austria, France, Ireland, UK). Thus water protection is an important factor in consideration of contaminated land impacts in all countries. Some countries are still developing specific legislation and policies on contaminated land (e.g. Greece, Ireland) while those countries that have a longer history of dealing with soil and water pollution issues have integrated the two areas (e.g. Denmark, Finland, Netherlands, Switzerland).

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[7] The ConSoil 2000 Case Study centred on an area of the Bitterfeld District of Saxony-Anhalt in Germany. Here long-term industrial pollution has resulted in wide spread pollution of soils, river sediments and groundwater with a variety of industrial chemical by-products. Teams from four separate countries prepared an outline study of how they would deal with the problems of remediation from their own legislative and procedural perspectives. These studies together with a description of the area and an appraisal of the reports is presented in a supplement to the proceedings of ConSoil 2000.

There is significant variability in the responsible decision-making bodies for contaminated land management and water management between countries. Most have a tiered system of regulatory control. With the exception of Belgium, legislation and overall policies are set at the national level. Some countries regulate the major polluting industries/activities at the national level (e.g. Norway, UK) but regulation is usually devolved to local authorities. These are often organised into two or three tiers (e.g. regional, prefectural, municipal). A few countries base their water management organisations on hydrological catchments (e.g. France, UK) which are not necessarily co-incident with political boundaries. The role of Environmental Protection Agencies (EPAs) or their equivalents is also variable. It ranges from where the EPA is a national body, but with local responsibility for management of the water environment and the regulation of some contaminated land remediation (UK), to where Regional EPAs only provide the technical support to the local authorities who implement/enforce the regulations (Italy).

For those countries that have a high strategic reliance on groundwater for water supply, groundwater is the primary receptor of concern when dealing with contaminated land (e.g. Austria, Denmark, Germany). The reliance on groundwater for public supply is variable regionally both within Europe and individual countries and is clearly related to the geographical distribution of aquifers. Hence the importance of groundwater in local decision-making may also vary. All countries consider water resources in general (groundwater and surface water) to be a main target. Most countries seem to distinguish between higher levels of protection needed in relation to abstractions as opposed to groundwater resources in general. Although some countries (e.g. Germany) adopt a precautionary approach towards groundwater in principle, in practice account is taken of the local circumstances. In others (e.g. UK) the main approach is based around site specific risk assessment within framework guidance on the protection of groundwater resources.

The Point of Compliance for Both Protection and Remediation of Groundwater Resources

All countries involved in the CLARINET project have specific policies and laws for the prevention and the protection of water resources. They have developed specific technical approaches for groundwater quality protection and groundwater quality remediation in relation to contaminated land sites. In general risk assessment procedures or recommendations are used, often those that are elaborated within contaminated land management frameworks. They integrate three main assessments: fitness for use, protection of the environment, and reduction of aftercare.

The main principles that underlie the risk assessment approach to water resources in the European countries are:

- definition of the sustainability of the resources,
- prevention of new pollution,
- remediation of past pollution where this is necessary to protect the environment or water users.

The following comments are based on answers from Denmark, France, Germany, Ireland, Italy, Norway, Switzerland and the UK who used a conceptual model illustrated in Figure 1 as an aid to describing their approach in a potentially real situation.

When faced with contaminated water resources, contaminated land stakeholders, and in some countries water supply managers, have specific choices depending on the circumstances. In relation with **new** activities that may be potentially polluting, groundwater protection is enforced:

- at the surface of soil (Denmark, France, Ireland, Switzerland for all kind of activities, Germany for waste disposals),
- at a monitoring borehole at or near the boundary of the site in Italy (unless more conservative measures, at the water table immediately below the site, are required by the public bodies),
- on a site-specific approach in Norway (no specific rule in this country).
- at the water table for List I substances in the UK where the groundwater is a strategic resource, otherwise on a site-specific basis taking account of the risks to groundwater resources and interconnected surface waters.

The behaviour of stakeholders when facing **historical contamination** of groundwater varies from country to country:

Denmark: If historical contamination indicates that it is impossible to identify the responsible polluter then limited public funds are used to remediate the contaminated sites according to priorities. The target in relation to groundwater protection is the groundwater resource itself and when the resource is protected then existing and future wells will be protected too. A step by step risk assessment is used to determine if soil contamination has to be remediated. At step 1 the groundwater criterion has to be satisfied immediately below the site and in step 2 and 3 the groundwater criterion has to be satisfied at a distance equal to one-year's groundwater travel, up to a maximum of 100 meters down-gradient.

France: The exposure point taken into account in the detailed risk assessment for groundwater resources varies depending on the particular situation:

at the water table immediately below the source of pollution in the case of uncontaminated aquifers,
at the receptor when the aquifer is contaminated on a large scale but is still potentially usable,
at or near the boundary of the site of the activity when the aquifer is contaminated but needs to be preserved as a drinking water supply resource.

Except for the first situation, the choice of exposure point taken into account in the risk assessment for water resources has to be discussed by the different partners (local authorities, those responsible for the site, drinking water supply providers, etc.).

Germany: The compliance point can vary depending on the situation. It is usually at the water table immediately below the site, or at a monitoring borehole at, or near, the boundary of the site, but can be a monitoring borehole between the site and the receptor.

Ireland: The setting of remediation targets for groundwater in Ireland is dependent on the type of contaminant present in the soil and groundwater and is based on the Risk Based Corrective Action (RBCA) approach. In the case of a gasworks site the contaminants in the soils are either removed or treated such that they do not pose a significant risk to groundwater. The groundwater itself is treated in some cases and target values are set for the discharge to sewer and also for the groundwater at the boundary of the facility. Another example would be the accidental or historic discharge of chlorinated solvents into groundwater. In this case the remediation target would be set at the receptor as one of the remediation technologies that is effective for this type of contaminant is monitored natural attenuation.

Switzerland: Generally the targets for remediating any kind of contaminated site polluting groundwater are set at a monitoring zone at or near the boundary of the site of the activity (zone in the immediate downstream of the site in question). In certain cases where groundwater pollution caused by a specific site has already reached a receptor, such as a drinking water well, this point of compliance has also to be taken into consideration. This is because the Swiss legislation requires that no public drinking water supply wells should be affected by pollutants derived from a contaminated site. In such cases the remediation of a contaminated site has to take place to ensure that no pollutants will affect the wells in question in the future as well as meeting certain standards in the groundwater immediately downgradient of the contaminated site.

United Kingdom : In the UK each circumstance is considered on a site-specific basis. Remedial targets are set using a tiered risk assessment tool which considers the receptors and the natural processes of attenuation which may act on the pollution. The compliance point varies according to the importance of the groundwater:

- strategic drinking-water source – groundwater at or near site boundary (unless adopting natural attenuation is cost beneficial when the compliance point can be extended to the receptor);
- non-strategic but locally important – at the point of abstraction;
- where it is in continuity with surface waters – at the surface water receptor.

The observed differences of approach towards groundwater protection in these six countries clearly are dependent on differing national policies which have their origin in the different cultural, social and industrial history of the respective countries. An in-depth analysis will be conducted during the following months for the final CLARINET report.

Conclusions

It is clear that different countries approach groundwater protection and the remediation of contaminated groundwater in slightly differing ways. These do not seem to be due to any differences in the problems faced or the understanding of the basic hydrogeological processes. They are more related to cultural differences, differing perspectives on the importance of groundwater as a source of drinking water and a differing historical background of the development of environmental protection regulations. Some of them may well be important in the long run. For example there is clearly no uniformity yet in the adoption of natural attenuation as a remedial technique across Europe. Reluctance by some countries to accept NA may be partly because they wish to understand the science more but it may also be because they have a more inflexible approach to groundwater protection or that they place the compliance point closer to the pollutant source. The final CLARINET report will attempt to elucidate some of these matters in more detail.

In most of the cases the impacts of contaminated sites on the environment are restricted to the close vicinity of the sites in question. Local soil contaminations affect the quality of rivers and/or aquifers flowing through different countries only in particular cases. From a scientific point of view a certain pressure on the standardization of national policies with regard to definitions (e.g. point of compliance) or assessment procedures could thus only emerge from this relatively small part of the contaminated sites problem. As the European Water Framework Directive is designed to integrate water protection issues across national boundaries future harmonization steps will strongly depend on the development of its application.

3.3 MONITORED NATURAL ATTENUATION – A NEW WATER PROTECTION STRATEGY?

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Abstract

Throughout the last years discussions on innovative remediation technologies sometimes seemed to be confined to 'Monitored Natural Attenuation'. These discussions have been endangered to transfer several misconceptions as well as generalised statements neglecting the complexity of natural processes. The topic 'Monitored Natural Attenuation'(NA) is less a debate on a "new" technology, but part of the permanently recurring discussion on risk assessment procedures and criteria. Actually regulatory approaches on MNA in Europe show still a wide variety. Anyway it turns out clearly that it is necessary to improve scientific and technical knowledge on the interactions of pollutants, hydrogeological and biogeochemical factors. Improved knowledge will bring about new procedures to define acceptable levels of (residual) pollution and remediation objectives on a site-specific basis.

Introduction

During the 90'ies, after the experiences of a decade or more dealing with contaminated land, several industrialised countries began to change their strategies . It got unusual to talk about 'clean-up measures' but it was learnt to spell 'RBCA' (risk based corrective action). At last a mirror of environmental politics.

1. MNA – A New Remediation Technology ?

The starting point for the development of MNA-strategies have been pollutions by hydrocarbons. Oil spillages are generally the most common accidents causing soil pollution. Compared to other pollutants hydrocarbons are at a wide range easily biodegradable. Therefore plumes in groundwater environments are, although hydrocarbons show a high solubility, usually rather short. Accordingly in 1998 the first published MNA-Guidance was 'for Remediation by Natural Attenuation at Petroleum Release Sites' [1]. Meanwhile guidance papers do not focus on specific pollutants anymore but try to generate general ideas and strategies for a 'remediation technology'.

A review of known groundwater pollutions and the sequences of investigations and negotiations can show easily that ideas are quite old and common. At first there is an observed accidence or someone turns up with a bad result of a soil or a groundwater sample. It starts up series of investigations, reports and discussions. After a more or less long period someone has to take a decision. Basis for the decision is a conceptual model of the site, which is derived like

- the soil at the site is polluted,
- groundwater downstream the site is polluted (or not),
- the plume is expanding, stable or shrinking and
- wells can (not) get or are affected by the plume.

To take a decision for further actions there are two questions to answer:

- Is the environmental situation bad (not acceptable)?
- Is there a receptor at risk ?

If the environmental situation is bad but a remediation is perceived to be infeasible, not possible within reasonable timeframes or unreasonably expensive it has always been the reaction to monitor the situation. If there is a receptor at risk it would be necessary to look for options to minimise risks and monitoring can not contribute to risk reduction.

2. MNA – National Approaches In Europe

European countries have different points of view when discussing MNA as a strategy or remedial technology. Referring to these discussions MNA could be seen as
a part of a phased approach to risk assessment,
a monitoring technique or
a remediation technology.

Only the Netherlands and the UK [3] have published a methodology for assessing NA, although Germany has one in preparation. Other countries are currently reflecting on the best acceptable approach. Most authorities are still considerably sceptical and reserved with regard to the controlled use of NA processes for the remediation of water (and soil) pollution related to contaminated sites. In most countries MNA is not acceptable as an overall remedial panacea but may be applied on a site-specific basis where the evidence can be substantiated. The “three lines of evidence” approach is generally being adopted by countries who have developed or are developing guidance or protocols (Netherlands, UK and Germany):
documented loss of contaminants (for shrinking plumes),
an indication that biodegradation is actually realised in the field (for shrinking or stable plumes),
laboratory assays showing that micro-organisms in site samples have the potential to transform contamination under expected site conditions (or use modelling to predict results).
In other countries the approach is more cautious. Most countries consider from a policy point of view that MNA should solely relate to mass or toxicity reduction (e.g. Austria, Finland, France, Germany, Netherlands, and UK). Dilution is generally not accepted but in practice it is difficult to separate it from the other factors. Policies have to face this reality in order to be applicable and in the UK, for example, dilution can be taken into account for remedial target setting but not as a justification for MNA itself. Thus it can play a role as a potential option within a risk-based setting.
All countries consider that monitoring of NA has to be planned in order to demonstrate in the longer term that NA is continuing and will lead to the remedial objectives as defined in the risk assessment performed on the site. More active, additional treatment may need to be adopted and contingency plans implemented if NA is not seen to be appropriate or effective.

3. MNA – Constraints

To consider MNA as an accepted approach within different national groundwater protection strategies various boundaries are under discussion. Limits can be given under consideration of a range of aspects such as:
existence of sensitive receptors (e.g. drinking water supplies)
destructive processes have to prevail (loss of contaminants is the governing factor)
combined approach to ‘source control’-measures (e.g. isolation or remediation of hot spots to minimise the load of the contaminant)
geographical scale (within the site boundaries, stable plumes or minimising further expansion?)
time scale (30 or 50 years to achieve the remedial goals or comparable time scale to active measures?)

attributes of affected aquifers (those not currently considered as strategic or irreplaceable?)
characteristics and behaviour of contaminants and breakdown products (authorised for substances which can be attenuated - based on existing case studies or experiences?)
age of the pollution (restricted to historical pollution?)
Throughout Europe there are very diverse natural conditions and environmental, economic and social needs. Therefore boundaries to the use of MNA have to be defined at a national level but should at least also refer on the ideas of the European Framework Directive on Water Policies. With respect to groundwater protection and owing to the natural time-lag in its formation and renewal, the task of contaminated land management should mean a stable long-term planning of protective and curative measures.

4. MNA – Practical and Regulatory Criteria

Besides discussions on technical criteria a couple of practical and regulatory criteria have to be considered. As MNA is an approach accompanied by higher uncertainties, it is necessary to develop a contingency plan, which can be implemented if NA proves to be ineffective. The long-term liability of the polluter has to be resolved. Therefore budget provisions should be sufficient for the monitoring as well as for the contingency plan. Security of monitoring boreholes and access have to be guaranteed by third-party agreements.

Conclusions

Main objectives of environmental protection are to preserve, protect and improve the ecological quality of soil and water and to establish a sustainable way on utilisation of these natural resources. This brings up a requirement to improve the ideas on 'old' contaminated sites clean-up programmes and to improve 'new' risk management strategies. Natural Attenuation is not a new strategy but a contribution of nature. It can be abused as may a simple 'to-do-nothing & save money'-approaches. But an enhanced understanding of natural processes and a better basis to define acceptable levels of residual pollution and remediation objectives on a site-specific basis would be clear benefits.

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3.4 RTD NEEDS FOR IMPROVING GROUNDWATER REMEDIATION TECHNOLOGIES

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Abstract

A coherent RTD strategy is needed in order to obtain cost-effective methods and improve sustainability of groundwater remediation. The remediation time frame for a groundwater remedy should be kept inside reasonable limits. The right application of the existing techniques, as well as the development of new ones to be applied on problematic aquifers (low permeability, fractured formations, high depths), is shown to be a main goal for future investigation programmes. Comparative studies to determine the effectiveness of multitechnique sequences where biological, chemical and physical methods are combined are also lacking.

Keywords: Remediation, aquifer, risk-orientated approach, unsaturated zone, CLARINET, RTD Needs

Introduction

Groundwater is a vital, natural resource within the European Union. Water treatment and purification processes have been focused on heavy metals contamination, but nowadays the effect of a broader range of pollutants in groundwater protection and/or remediation policies must be considered to obtain a sustainable development.

There is a need to prevent and/or reduce the effect of contaminated land on water resources. The Water Framework Directive, finally agreed in June 2000, demands the development of cost effective in-situ treatment technologies. The Member States must prepare a programme of measures to attain good surface water and groundwater status by the end of 2010. To reach this ambitious goal, not only the application of innovative technologies for the remediation of contaminated groundwater must be promoted, but field demonstrations, bench studies and technology evaluations are needed. Active treatment technologies and passive containment technologies must be investigated for use in cleaning up contaminated groundwater

The Water Framework Directive and future regulations derived from it establishes the necessity of remediation of groundwater masses but, in practice, achieving groundwater cleanup objectives is not possible due to the extent and persistence of contamination. In these situations of technical impracticability even if a cleanup approach is technically feasible, the scale of the operation (EU wide scale) may make it impossible so a more **risk-orientated approach** may be used.

1. RTD Needs to Optimize Existing Technologies

Before a specific remedial technology has been selected, some investigation must be carried out, to determine the extent of the contamination and pollutant fate and transport. In this context the relationship between surface water and groundwater is an important issue to be studied. The following issues may be addressed:

- Development of simple (non-intrusive) methods of site investigation.

- Methods to asses the natural potential of soil and the unsaturated zone to attenuate contaminants, and techniques to monitor the processes.

- Key processes controlling the quality of groundwater/surface water and their interactions.

- Interactive metabolism of contaminants in aquifers.

- Free phase fate and transport.

- Modelling of aquifers paying special attention to fractured and non-homogeneous ones.

2. RTD Needs for Improving Remediation Technologies

We are far from having a set of techniques able to decontaminate every kind of aquifer in a sustainable way. In this regard, research needs for improving the effectiveness of groundwater remediation techniques have been short-listed.

- Remediation in low permeability formations and those aquifers where low hydraulic conductivity hinder the use of classic techniques.

- Influence of rising groundwater tables in urban areas where there is a land contamination.

- Methods to asses interaction of seawater with contaminated soil in coastal aquifers.

- Remediation techniques for inorganic substances and compounds, since most of to day techniques are specific for organic contamination.

- Genetic information needed by specialised microbes to produce the required enzymes in order to degrade specific contaminant substances, as well as effectiveness of genetically manipulated organisms.

- Vulnerability of microbes to certain substances that produces inhibition of bioremediation techniques.

- Toxicity of by-products generated by the application of remediation techniques.

- Development of new non aggressive methods in order to increase the solubility of contaminants to enhance their movement and removal, avoiding the destruction of the basic aquifer structure as well as the undesirable presence of residual reagents.

- Improvement of methods for dissolving heavy metals in their metallic state, present in the pores of aquifers.

- Optimisation of remediation multitechnique sequences.

- Analysis of geochemical stability systems in order to determinate the dissolution / precipitation potential of metals according to the Eh-pH changes produced in aquifers during the application of remediation techniques.

- Degradation processes of contaminated vapours in the vadose zone, as sub-products of remediation.

- Investigation on new plants with potential phytoremediation application, as well as genetic engineering to improve their natural capabilities.

- Determination of processes of accumulation and degradation through plant metabolism, in order to determinate the enzymes that breakdown complex organic molecules into simpler $C0_2$ and H_2O ones. The goal of this investigation should be the synthesis of those enzymes.

- Recovery of metals from enriched plant material in phytoremediation techniques, intended for their removal from the environment and / or the food chain.

3. RTD Needs for Improving Monitoring Techniques

Monitoring of remedial performance is essential to verify success of aquifer cleanup operations as well as to detect changes in environmental conditions, control the presence of toxic transformation product and verify possible undesired spreading of the plume. A facility should monitor until the groundwater cleanup levels are met at the point of compliance. Furthermore, to evaluate data and support decision-making, statistical methods should be also improved.

Basically, systems of groundwater quality control are focused in the definition of a monitoring network, and precise detection techniques of pollutants.

For a proper definition of a control network hydraulic and hydrogeological characteristics of the aquifer should be determined prior to remedial activities, so concentration, distribution and movement parameters of contamination in the subsurface can be modelled. To achieve this goal, new investigation programmes on hydrogeology and aquifer modelling should be carried out.

Once the monitoring network has been designed and performed, accurate enough analytical detection techniques should be employed in order to detect small concentration changes. Development of new techniques and improvement of previous ones should be achieved.

Conclusions

The Water Framework Directive issues the need of remediation of damaged groundwater masses to attain good quality status by the end of 2010. Reaching those groundwater cleanup objectives in time is fair unattainable due to technical and scale impossibilities. However an orientated approach may be achieved, developing new remediation technologies, optimising the application of existing ones and using proper monitoring techniques. Investigation should be focused, among other, on problematic aquifers where present day applied techniques have failed due to their heterogeneous hydraulic behaviour or high operating depths, as well as the application of new technologies as genetic engineering in order to improve bio and phytoremediation techniques. Typifying proper remediation multitechnique sequences shows to be a main objective in order to optimise the existing techniques.

It is likewise important to improve the knowledge state of aquifers to be cleaned up, by mean of hydrogeological investigation and modelling, prior to the application of remedial activities and the establishment of monitoring networks. The lasts are essential to verify the success of cleanup operations, and in that way an extra effort should be carried out to improve the design, the data processing and the analytical pollutants detection techniques.

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4 BROWNFIELDS REDEVELOPMENT – A WIDER AND FUNDAMENTAL CONTAMINATED LAND ISSUE

4.1 BUILDING ON CONTAMINATED LAND – PROBLEMS AND SOLUTIONS

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Abstract

Over the past decades the “Brownfields” issue has been a particular topic of discussion in the traditional industrial regions of Europe. Today many European cities are affected. Although the underlying conditions are different, there are derelict industrial sites in the traditional industrial centres and in metropolitan cities, as well as in peripheral locations. These different conditions also led towards different problems and solutions to support redevelopment. Typical types of redevelopment projects will be presented in this intervention.

Introduction

***Brownfields are sites that**:*

- *have been affected by the former uses of the site and surrounding land*
- *are derelict or underused*
- *have real or perceived contamination problems*
- *are mainly in developed urban areas*
- *require intervention to bring them back to beneficial use (CLARINET, 2000)*

Due to a lack of definitions and to the fact that the term brownfields has been used in different contexts and countries, there are only rough estimations available on the extent of brownfields across Europe. Various brownfield figures are available in response to one of the questionnaires within CLARINET working group 1: For example, in Germany there is about 128,000 hectares, in the United Kingdom 39.600 ha, in France 20.000 ha, in the Netherlands between 9,000 and 11,000 hectares, and in Belgium/ Walloon about 9,000 hectares of derelict land were estimated or identified.

Brownfield redevelopment is a complex process faced by the number of actors and interest groups involved in the decision making process. It is a common task of environmental restoration, land use planning and economic policy. The presence of urban brownfields is a challenging issue for national, regional and local stakeholders, in terms of:

- revitalisation of former industrial sites in the urban and regional context,
- remediation of the environment
- reintegration of rehabilitated sites into the economic cycle

Over the past decades the “Brownfields” issue has been a particular topic of discussion in the traditional industrial regions of Europe. Today many European cities are affected. Although the underlying conditions are different, there are derelict industrial sites in the traditional industrial centres and in metropolitan cities like London and Barcelona, as well as in peripheral locations such as the Brandenburg lignite fields. These different conditions also led towards different problems and solutions to support redevelopment. The wide range of different after-uses in the selected cased studies detailed below reflects quite specific considerations for the needs of urban and economic system. In general, the focus on industrial after-uses of the 1980s has changed towards the mixed and flexible after-use concepts of today. Typical types of redevelopment projects will be presented in this intervention.

Traditional Industrial Areas

As a result of the massive decline in industrial jobs in the coal, steel and textile industries at the beginning of the 1980s, governments had to actively promote structural change in industry. Comprehensive strategies and programs of derelict land revitalisation have been developed, particularly in the traditional industrial regions of the United Kingdom, France (Lorraine, Nord-Pas de Calais), Germany (Northrhein-Westphalia) and Belgium (FERBER, 1995). Due to the dominance in these regions of the coal and steel industries very large sites, having a low land value and high rehabilitation and decontamination costs are left derelict. Here, Government intervention was essential as property market forces alone were not robust enough to solve the problem. Since the beginning of the 1980s in the UK, France and Germany, initiatives have been developed which favour a regional derelict land policy and specific derelict land recycling programs. These initiatives were triggered on the one hand by increasing awareness of the negative economic and ecological effects of the derelict sites and on the other by recognition of the positive development potential for such sites.

Initial objectives related to structural policy are also central to all the case studies reviewed. Brownfields are often identified as an obstacle to investment, however for many municipalities they also constitute an important economic development potential although one which is difficult to mobilise. Most of the special programs and single projects reviewed also offer approaches to solving urban development, social and ecological issues. These include:

- restricting greenfield consumption by re-using brownfields,
- functional and design improvement of the affected urban structures by eliminating the derelict sites and associated measures aimed at general urban renewal,
- preserving the architectural heritage of the industrial revolution by finding new uses for historic industrial buildings,
- increasing the skills of unemployed people by derelict land recycling, via the creation of employment opportunities, and
- improvement of environmental quality, e.g. by encapsulating or removing contaminated soil and restoring the landscape distorted by industrial use.

Growing Metropolitan Areas

The economic strong metropolitan areas in the European Union are characterised by a dynamic land market in the wake of the growing service sector. Industrial uses dating back to the 19th century are subject of speculation and have often been closed or moved to peripheral areas by the urban sprawl process. Together with derelict large-scale railway and harbour infrastructure facilities, the brownfield areas are the main potential for urban development but also of speculative land banking. The interest, use and ownership conflicts resulting from such a situation lead to large areas of derelict land in urban areas. Thus Brownfields have been identified in most European cities. The strategies used focus on urban planning with large-scale projects being driven by architectural competitions, master plans and investor planning. Problems related to derelict land, i.e. land for building and infrastructure

development, are often inadequately considered. This can lead to considerable difficulties and on occasion, complete project failure.
Typical projects are

- the transformation into housing areas including the conversion of industrial buildings into loft apartments
- the development of shopping centres and office buildings
- leisure uses and urban green spaces

Rural Areas

Rural areas within the EU also contain individual derelict sites of a locally limited dimension, which may be very significant for the municipality concerned and were mainly connected with agriculture, forestry or mining. These activities may have been undergoing a consolidation process resulting in the abandonment of many sites. Recently, many former military sites have been released to the market due to tremendous political change and related political relaxation. The municipalities affected by such processes are often unable to solve the problems presented by abandoned sites and are reluctant to develop revitalisation activities. The necessity to develop strategies and programs is also often not recognised on regional or national level. This means that these areas are simply left as they are, unless funds are provided from the European Regional Development Fund.
Typical projects are

- the recultivation in relation with (industrial) tourist projects
- community uses by the public sector

Conclusions

The review of national approaches for the redevelopment of brownfields in Europe shows that the problem is clearly identified in many countries and action have been taken. However, such action is generally not always based on a national strategy but rather relates to single project or regional efforts. Brownfield project practice in Europe demonstrates a wide range of different approaches in specific urban and economic contexts. The general overview indicates that in most areas the costs for redevelopment will exceed the benefits. Therefore european regions and cities will need specific programme support, including different models for funding.

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4.2 BROWNFIELDS AND SUSTAINABLE DEVELOPMENT IN THE CONTEXT OF URBAN PLANNING

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Abstract

Across Europe, the presence of derelict land is subject of concern in many countries. Brownfield sites present particular challenges to national and regional policy makers in terms of bringing the land back into beneficial use and in terms of cleaning up contaminated soil and groundwater. In this respect successful brownfield redevelopment policies and strategies particularly need the combination of environmental approaches and spatial and urban planning approaches. To provide such a link between environmental and urban planning issues, a specific working group 1 on urban brownfields has been set up within the CLARINET project.

Introduction

Contaminated Land Management has been in the core of environmental research for almost 20 years. Approaches and solutions to cope with the contamination of soil and groundwater have been developed and implemented on a broad scale across Europe. Most of the approaches have in common to take action on the assessment and removal/reduction of hazards for human beings or the environment. Environmental concerns are the main trigger for these activities. Removal and reduction of hazards, however, is not finally sufficient to prepare the land for reuse and to attract potential new investors. For this purpose some wider spatial and urban planning, economic, legal and social aspects need to be included and co-ordinated within the whole land reclamation process. This broader approach of land reclamation is generally characterised as brownfield redevelopment. It aims specifically at bringing derelict and/or formerly contaminated land back into beneficial use. For the purposes of its own work, CLARINET Working Group 1 has agreed on the following definition, which is intended to describe the full context of the environmental, economic and planning issues that are involved:

Brownfield sites
- have been affected by the former uses of the site and surrounding land
- are derelict or underused
- have real or perceived contamination problems
- are in mainly or partly developed urban areas
- require intervention to bring them back to beneficial use

Researching on this issue means working along the major factors which may successfully control this process. The Risk Based Land Management (RBLM) approach, derived by the CLARINET network, for the first time provides a conceptual outline on this broader subject from the viewpoint of the contaminated land manager. Brownfield redevelopment however goes even beyond this approach. Land planning being performed only from the angle of land contamination does not appropriately meet the context of the broader brownfield vision. The redevelopment of brownfields needs an integrated and interdisciplinary approach bringing all stakeholders together working co-ordinated towards one solution. Insofar, brownfield redevelopment is also considered to represent a major tool on the way to a sustainable development. The presence of derelict land has adverse effects not only on the environment but also on the economic and social health of a city or a region. However, such general understandings are still not in line with current practice in many industrialised countries. In Germany, alone, an estimated to 129 hectares daily of greenfield land is lost for building purposes. Urban sprawl and the spatial separation of different land uses are ongoing and lead to an increasing need for mobility of the public.

Brownfields in Europe

In the Member States of the European Union there are no precise definitions about brownfields. Some countries have worked on national approaches to describe the scope of derelict industrial sites, including “rehabilitation”, “re-use”, “regeneration”, “modified use”, and “revitalisation” However, direct comparison is difficult.

Due to a lack of definitions and due to the fact that the term brownfields has been used in different contexts and countries to mean several different things, there are only rough estimations available on the extent of brownfields across Europe. Many countries systematically collect information only on contaminated sites. Other countries have made systematic procedures on the calculation of the real extent of brownfield sites in terms of estimating the total size of land that is covered by brownfields.

Various brownfield figures have been collected within the work of CLARINET working group 1: For example, in Germany there is about 128,000 hectares, in the United Kingdom 39.600 ha, in France 20.000 ha, in the Netherlands between 9,000 and 11,000 hectares, and in Belgium/ Walloon about 9,000 hectares of derelict land were estimated or identified.

Other EU countries supplied information about the number of former industrial sites that are suspected or known to be contaminated. (EUROPEAN ENVIRONMENT AGENCY (EEA), 1999) For example in Finland, there are about 20,000 industrial and other sites, in Spain there are about 4.000 sites, Ireland between 2,000 – 2,400 sites and Portugal more than 2,000 sites. For other countries, like Greece, Austria and Italy the problem of brownfields is relevant, but there is no general data available yet.

In the past the “Brownfields” issue was a particular topic of discussion in the traditional industrial regions of Europe. In general terms it can be stated that, the more a region or a country is affected by the presence brownfields the more systematically specific approaches have been developed and implemented. For instance, in countries like the UK, France, Germany, Ireland or Belgium special brownfield initiatives have been developed since the beginning of the 1980s. They favoured regional derelict land policy and created specific brownfield redevelopment programs. These initiatives were triggered on the one hand by increasing awareness of the negative economic and ecological effects of derelict land and on the other by the recognition of the positive development potential for such sites. Examples are:

In Northern France, the priority was to remove derelict sites in order to restore an attractive outer appearance to the region and thus attract private investors for newly developed industrial “greenfield” sites. In this context, any re-use of the recycled areas and remediation of contaminated land was coincidental.

Ecological rehabilitation has been a successful theme for the Ruhr area. Here ecological damage is remedied by combining ecological priorities with economic objectives. The aim was to develop environmentally-friendly industry and to mobilise areas which can be re-used by industry..

Classical objectives of economic promotion – establishment of business and industrial parks, provision of new housing, and job creation – are the focus of UK government policy. Funding has been largely focussed on the renewal of inner-city industrial sites, initially with a preference for industrial re-use, but more recently with an increased focus on housing developments.

Conclusions and Recommendations

To promote the redevelopment of brownfields, some European governments have developed focused regeneration policies which have contributed to the redevelopment of significant numbers of brownfield sites and invested public monies into complementary remediation and regeneration strategies. However, the need for future action at all levels of government for the task of brownfield redevelopment is still obvious. Research and development on this subject can contribute significantly to the derivation of best practice approaches for brownfield redevelopment. CLARINET working group 1 has identified some priority research recommendations along the main factors of influence, like policy and programs, future use/planning procedures, site preparation/technical procedures and economic viability.

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4.3 ENHANCED REHABILITATION OF BROWNFIELD SITES – EUROPEAN VISIONS FOR THE FUTURE

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Abstract

This paper presents recommendations for future research needs from the study by the CLARINET Working Group on Brownfields. It also identifies the potential for future cooperation in development of solutions, which continues the CLARINET theme of international exchange and synergies.

Introduction

Brownfield sites represent a complex problem. This is often strongly influenced by problems of land contamination, but there are many much wider aspects that need to be integrated to achieve effective solutions.

Brownfield sites are not a new problem, but continual changes in industrial patterns, as well as in the economy and development patterns, mean that they continue to present major challenges, both now and in the future. CLARINET working group 1 has identified priority research recommendations to assist in promoting and developing solutions to deal with these challenges. These are discussed below.

The Working Group is also part of a much wider dynamic looking at issues of brownfield sites in Europe and elsewhere. This paper also outlines the potential for future collaboration to draw these different strands together.

1. Key Recommendations from Clarinet

The CLARINET analysis considers the main factors of influence on successful brownfield regeneration. This analysis and review of practice and tools was structured around 4 key aspects and for each the working group have identified areas for further synergy and enhancement of practice.

1.1 Site Preparation and Technical Procedures

Technical solutions to problems of land contamination have been developing rapidly over the last 10 or more years. From the perspective of brownfield application, there is now a clear opportunity to provide greater access to information on these solutions to achieve more impact in this wider area.

In addition, technical approaches in some specific areas can be critical to successful management of land contamination during brownfield redevelopment. In particular the need to ensure protection of the environment and to minimise the use of resources can be identified during initial site preparation phase. We recommend stimulation of guidance, new techniques and further assessment of policy and practice in:

- Management of redundant buildings – a key feature of brownfields which may present safety and environmental issues
- Demolition and recycling – to minimise potential environmental impact and conserve resources
- Contamination – preparation of integrated practical guidance and improved technical standards will help to transfer tools and experience to the brownfield sector
- Existing infrastructure – often not valued in designing new use of the land

1.2 Future Land Use Planning

Clearly, the main element of successful regeneration of brownfield sites is identification of appropriate after use. This is a component both of strategic planning, perhaps for a region, or detailed planning for an individual site. The working group identified key needs as:

- Practices for early identification of characteristics of the site and the way in which these can be best integrated into spatial planning decisions
- Ways of improving community participation in brownfield redevelopment, particularly for example in relation to risk communication
- Development of methods and skills to respond to the increasing importance of preserving industrial heritage in brownfield projects

1.3 Economic Viability

The cost of dealing with contamination and other legacies, together with the wider context of economic development that relates to brownfield sites, mean that the viability of site and regional projects can be a critical factor. Public funding is often needed to stimulate investment in brownfield areas.

The working group identified a number of key areas where new tools might assist in enhancing viability:

- Interdisciplinary cooperation – so that all factors relating to viability were identified and resolved in an effective way
- Project management – to achieve cost effective and low risk redevelopment
- Assessment of costs – better information on real costs and better techniques for determining costs and land values will help to ensure that factors such as contamination are addressed properly
- Funding – where analysis of types of funding and their effects and benefits will help to ensure that best use is made of public funds.

1.4 Policy and Programs

Brownfields are a dynamic area of policy development. The working group considered that some key areas would benefit from further research to provide a scientific basis for informing policy and programme decisions, including:

- Better information on extent of the problem and development of sustainability indicators for brownfield sites
- Review of strategic land management approaches
- Investigation into effects of positive stimulation of heritage, cultural and social aspects

Finally, the working group concluded that a key objective for the future will be to avoid continuous creation of new brownfield sites – using a combination of incentives and penalties so that effective recycling of land is stimulated.

2. The Future

The working group will present these recommendations and others in a detailed report. They hope it will stimulate further work, and particularly further collaboration at a European level.

This future collaboration would ideally involve a mix of stakeholders in exchanging information on existing practice, developing new tools and analysing complex issues of brownfield sites. Proposals are being developed to take this idea forward – in particular the CABERNET project has been conceived to provide a new network of contacts, focussing on outputs of particular relevance to the urban brownfield environment.

Conclusions

Exchanging information on existing experiences and working together to develop new solutions will help to deal with the complex challenges of brownfields, which need to integrate work on contamination issues with wider aspects. These new solutions will presents still further opportunities to turn brownfields from a problem to a future resource.

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CLARINET Working Group 1 Final Report (Draft), March 2000.

5 STRENGTHENING THE FOUNDATIONS OF A EUROPEAN RESEARCH AREA

5.1 PRIORITY RTD NEEDS FOR RISK BASED LAND MANAGEMENT

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Abstract

Major areas of research and technology development (RTD) needs have been identified by the European countries participating in the CLARINET network. These RTD areas will strengthen the scientific basis for the recommended risk based land management (RBLM) approach towards the sustainable management of contaminated land and groundwater. As a matter of fact, the review of research priorities for RBLM reveals the needs for efficient methods for characterization and long-term monitoring which are linked to human health and ecological exposure considerations, water resources protection and spatial planning issues. Research areas in the field of remediation technologies address the needs for sustainable remediation approaches in terms of environmental merit, energy and cost efficiency, after care, long term monitoring, verification of performance and decision support tools. The identified RTD priorities could be covered more effectively through international cooperation efforts. Networking for communicating and sharing approaches and practical experiences is a major need.

Introduction

Key-objective of CLARINET is to identify the means, by which management of contaminated land (soils, groundwaters, surface waters) can be applied effectively in a sustainable manner in order to:

- ensure the safe (re-)use of these lands
- abate caused water pollution
- maintain the functionality of soil and (ground-)water ecosystems.

Keeping in mind these goals, CLARINET has reviewed, through its country representatives, all the major gaps and most urgent needs in research activities on a national basis. Many research issues have been commonly identified by several countries as priorities. Issues identified are presented in the following and grouped according to the CLARINET – problem definition and problem solution – analytical framework. Problem definition research needs relate to the need for a better understanding of the Nature of Contaminated Land. This issue includes Site Characterization, Protection of Water Resources, Human Health Aspects and Ecosystem Functionality. An improved problem definition, in the RBLM concept, implies an improved assessment of risks according to land use and fitness for use requirements. Problem solution research needs are presented in the areas Remediation Technologies and Techniques.

Contaminated land risk assessment is still underpinned largely by scientific research done for other purposes. The nature of the assessment is to a large extent determined by the availability of these more or less useable scientific building blocks.

Whether current assessment procedures really address the question of risk in a rigorous, quantitative way may be questioned. Further development and integration of the building blocks needed for risk assessment is of the utmost importance if assessment is to be more than a mere sequencing of separate disciplines like soil and water sampling, chemical analysis, exposure modelling and toxicology. In a fully integrated approach, choices of toxicological endpoints must have consequences for the design of sampling schemes and exposure models, and vice versa. Uncertainties at each stage in the assessment should be recognised and may lead to the use of probabilistic or other techniques for dealing with uncertainty. Decision-support tools may provide guidance for risk managers to help balance reduction of uncertainties against the costs of additional investigation. Integrated risk assessment procedures have yet to be fully developed, and progress will depend on research in two main areas:

(a) The nature of contaminated land, which deals with the identification and analysis of pollution and its impact on human health, water resources and other environmental receptors; and

(b) The relationship between soil and water contamination and suitable for use, which specifies the conditions for sustainable landuse in urban and rural areas.

1 The Nature of Contaminated Land

This research area includes the development of techniques, methods and procedures to assess soil and water pollution (and their relationship) and to establish the scale and intensity of the pollution in such a way that the consequences for landuse and environmental protection can be assessed. Soil and groundwater pollution cannot be described by a set of fixed parameters. Pollutants may degrade, disperse and transform with time. Risks might decrease or increase in time, depending on landuse, soil and aquifer characteristics. The dynamic interplay between these factors must be understood in order to predict future impacts, to keep polluted areas under control, and to assess various options for remediation. Three interlinked themes for research may be distinguished: site characterisation, protection of water resources and bioavailability.

1.1 Site Characterisation

Site investigations should provide much of the data necessary for exposure analysis and risk assessment, and must also quantify the uncertainties associated with site characterisation. The linking of site investigation to exposure analysis and evaluation of uncertainties needs further development in most countries.

1.2 Protection of Water Resources

Groundwater is protected as a resource that should remain pure, as implied by the EU Groundwater Directive. There may be situations, however, where the application of this principle in environmental groundwater protection has become impossible due to the extent and persistence of contamination. In these situations a more risk-orientated approach may be used. Methods to predict whether soil pollution will in the long run migrate to groundwater, and to what extent groundwater pollution will disperse and affect abstracted or surface water quality, are of the outmost importance. Current practice is mostly based on geohydrological models. A broader scientific basis including geological, geotechnical and probabilistic approaches may yield substantial improvements. In particular, the transport of contaminants in the unsaturated upper layer of the soil and the behaviour of contaminants at the interface between the unsaturated and saturated zones both need further study.

1.3 Bioavailability of Contaminants in Soil and Groundwater

Bioavailability is a facet of the interaction between organisms (soil fauna, bacteria, plants) and their chemical environment. Soil characteristics partly determine bioavailability for organisms, and organisms in turn create their own environment by influencing soil properties. Current bioavailability research is too focused on abiotic aspects. Organisms are often modelled as a special form of soil organic matter which is exposed to water in the pore spaces of soil, and which does not respond to changes in the environment. Future research should critically test the applicability of simple abiotic bioavailability modelling and should consider the biology of the organisms involved more explicitly.

Another aspect that is not fully appreciated is that bioavailability may change with time. More research on ageing processes of polluted soils and on time dependence of bioavailability should be encouraged. Progress in this field should lead to cost-effective procedures for determining bioavailability of compounds as they exist in the environment.

2 Suitability for Use

2.1 Human Health Risks

The primary need among contaminated land risk assessors is for human toxicity data that adequately reflect the chemical forms, modes of delivery, exposure conditions and bioavailability found in the context of contaminated sites. It is recognised, however, that the quality and relevance of fundamental epidemiological and toxicological data are severely constrained by both cost and ethical considerations.

2.2 Risk Comparison

Research in this area may be seen as a key step in addressing the basic question: how significant are the risks associated with contaminated sites in relation to other risks, and on what factors do these judgements of significance depend? This area of research requires an innovative integration of scientific risk assessment methodologies and those of the social and behavioural sciences.
In addition, the valuation of risks and risk management options is a multidisciplinary field involving many areas of risk study, including remediation economics, insurance, law, ethics and policy. An important task here is to complement traditional cost–benefit and risk–benefit analyses with modern multicriteria decision methods.

2.3 Ecological risk assessment

Whereas human health risks concern the health of an individual, ecological risk has to address the health of populations of a multitude of species and ecosystems. Ecological risk is still based on the No Observed Effect Concentration (NOEC) concept and results of toxicity testing in the laboratory. There is at present no ecosystem theory that can serve as a framework for interpretation of NOEC data. Although human health risk assessment is also largely based on laboratory experiments with animals, there is a framework for interpretation in medicine, sociology and psychology, which is lacking in the ecological approach.

Many forms of landuse by humans also need a certain level of ecological functioning in soils, sometimes referred to as the life support system. In the derivation of landuse-based remediation goals, discussions about human toxicity dominate and the requirements of the life support system are often neglected. If more ecological research were devoted to the life support system concept this problem could be adequately addressed.
Another neglected ecological field is groundwater ecology. Groundwater reserves are under pressure from over-exploitation, and in some countries water shortages are already occurring. At present groundwater is protected as a source of drinking water. The ecological consequences of groundwater pollution are still poorly understood and would provide additional motives for groundwater protection.

2. 4 MODELS FOR RISK ASSESSMENT

Models are powerful tools for integrating the various elements in a risk assessment, e.g. site characterisation, fate and transport of contaminants, exposure assessment and risk estimation. They may be used as tools for site-specific assessment of a given contaminated site, or to derive generic screening or guideline values. Models, however, are abstract representations of complex systems, and are based on numerous assumptions. It is therefore of the utmost importance that models and submodels should be validated and tested in real-world situations, either in contaminated land risk assessments or in special research projects. Field-testing and validation of models raises important questions about the precision and accuracy of model predictions. In particular, can we expect accurate estimates from the overall assessment in view of the many uncertainties in source characterisation, in exposure assessment and in the toxicological basis for tolerable daily intakes?
From a general methodological point of view an important area for research might be a study of how risks estimated from site-specific exposure modelling differ from those estimated using generic criteria. What do the results of an assessment actually mean? And how does exceeding a toxicological reference intake or soil screening level relate to the probability of human health or ecological effects occurring? From a risk characterisation point of view it is important to know how accurate one could hope to be on the probability of an effect occurring, as well as on the magnitude of the effect. This in turn would influence risk communication.

2.5 Risk Perception and Communication

Use of the results of scientific risk assessment in environmental decision making must take the perception of various risks and other social issues into account. The development of coherent risk communication strategies is important: How should we communicate the results of risk assessment and the choice of a solution to those who are or feel themselves to be at risk as a consequence of (potentially) contaminated land? And how should we communicate with other stakeholders whose perceptions may be very different?

3 Finding the Right Solutions

Large excavations and offsite treatment or disposal were used to remove the pollution to make sites suitable for use as fast as possible. The price for these solutions is often very high, not only in terms of money but also in terms of environmental impact. Soil has a natural capacity to biodegrade certain substances. If needed this process can be stimulated. In such cases so called in-situ technologies could be applied which meet lower costs and have a smaller overall environmental impact.

Scientifically valid criteria for sustainable use of soil and groundwater in extensive remediation projects are needed to support the decision makers to find the right balance between contaminated land remediation and environmental protection. For example, if a risk assessment shows that there remains sufficient time and the self-remediating properties are present in the soil, one could also decide to adopt an extensive approach; in such case a dedicated program for monitoring and control is necessary. Some of the requirements are already apparent:

- Biodegradation has to coexist with surrounding land uses
- The underground geohydrological 'climate' needed for optimal results may lead to restrictions in land use over a larger area
- Spatial planning, which mainly addresses the surface of the land, may have to extend into deeper layers.

4 Needs for Sustainable Contaminated Land Management

A large amount of research dealing with the scientific building blocks of risk assessment has been reviewed by the Concerted Actions CARACAS and CLARINET. Risk assessment, risk analysis, policy making and decision making are also extensively studied in the social sciences and in psychology. Attempts to integrate the scientific and technical framework and socio-psychological aspects of risk analysis have had limited success, but a decision theoretic approach might yield valuable results.
Risk assessment for contaminated sites is a rather loose assemblage of concepts and methods borrowed from various disciplines. Until recently, the research community seems to have had little interest in studying fundamental issues related to integrating the various building blocks of contaminated land risk assessment. Developments in this area are being driven by regulators who need better decision-support systems. The limitations of toxicological reference values, exposure modelling and soil and groundwater sampling are not widely understood, especially by the generalist type of scientist or engineer often involved in site investigation and risk assessment.
Risk assessment is not yet recognised as a coherent scientific discipline. Further integration of the building blocks will be achieved under pressure from environmental policy makers with the support of industry. International cooperation is important in this for a number of reasons:
to avoid unnecessary duplication;
to provide a wider basis for scientific peer review;
to provide a common database for physico-chemical and other basic data;
to promote international cooperation on the assessment of toxicity of substances in soil and groundwater;
to promote mutual understanding of the way science is put to work in developing and delivering national policies.

International cooperation in environmental science and policy is at present considered necessary to solve large-scale problems. Some people feel that soil and groundwater problems are local problems and therefore international cooperation is not so important. This is a rather naive point of view. Global problems evidently need political solutions at an international level. Local problems need solutions that reflect local needs and circumstances, but this does not mean that international exchange of ideas about how to tackle these problems is of limited value. Reinventing solutions for soil and groundwater problems in each country is simply a waste of time and money. Common political solutions may not be necessary or desirable, but exchange of technical and scientific approaches between countries is extremely valuable.

Improving risk assessment for contaminated sites depends not only on the results of research projects. Other requirements have to be met, of which the most important are:

– training of risk assessors and decision makers;
– networks for communicating new approaches and practical experiences;
– linking fundamental science to real-world problems.

Conclusions

The analysis of perceived RTD priorities among the European countries in the field of risk based management of contaminated sites, draws to the following conclusions:

- Research is needed for an improved and efficient insight in contamination problems: cost effective investigation methods; better understanding of chemical, physical and biological processed governing contaminants fate especially in complex groundwater scenarios such as in the presence of mixtures of chemicals, NAPLS and particular environments such as in inhomogeneous and coastal aquifers and in the unsaturated zone;
- Research is needed in the predictive exposure modelling, epidemiological and toxicological areas in order to assess relative importance of diverse human health risk contributions and of integrated effects;
- Several aspects in the ecosystems functionality mechanisms and interactions need to be studied in order to build an ecosystem theory which would account also for ecological quality requirements of soil and groundwater in relation with landuse;
- In the field of remediation technologies and techniques, needs are identified in decision support tools that would account also for long term efficiency and aftercare evaluations. Research for innovative technologies seems to focus mainly on remediation of complex, non homogeneous aquifers, on stabilisation of landfill emissions and on integration of different techniques;
- Other needs refer to the development of long-term land planning protocols, risk communication strategies, training and networking.

The overall conclusion from CLARINET RTD needs analysis is that major efforts should be dedicated in the near future to the achievement of a contaminated land management framework. This framework should rely on the development of robust decision support tools and strategies aimed at facilitating communication between different stakeholders and appropriate and beneficial use of available science and technology.

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5.2 ANALYSIS OF RTD PROGRAMMES ON CONTAMINATED LAND MANAGEMENT

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Abstract

This paper summarises the results achieved by CLARINET Working Group 4 on the co-ordination of RTD needs at a European level. It evaluates the current state of the art in RTD funding on contaminated land and groundwater related issues in Europe and provides recommendations for a future co-operation of RTD Programmes in the European Union.

Introduction

The conceptual paper by CLARINET on sustainable management of contaminated land (Vegter et al.) presents a general vision of the development of contaminated land and groundwater policies in EU countries. According to this paper, contaminated land and groundwater problems can be viewed from two policy perspectives. Polluted sites that endanger human or ecological health are generally considered as an environmental problem. On the other hand, derelict land that does not cause any immediate risk may be considered as a spatial planning problem. The major trend in policy development is to address environmental issues and spatial planning issues simultaneously. Efforts to develop such integrated risk-based approaches have resulted in a shift in the attention of policy makers from the assessment of problems to the formulation of solutions that will meet the needs of society. These developments need to be based on comprehensive scientific knowledge. The development of such knowledge is managed through national RTD programmes in various European countries, and through the EC RTD Framework Programmes at an EU level.

The Role of Concerted Actions for RTD Co-ordination

Since 1997, the European networks CARACAS (Concerted Action on Risk Assessment for Contaminated Sites in Europe) and NICOLE (Network on Industrially Contaminated Land in Europe), have identified priority research needs, to increase the currently existing scientific basis for sustainable contaminated land and groundwater management in Europe (CARACAS/NICOLE 1997; Ferguson et al. 1998). These recommendations have been recently updated and further defined with the CLARINET RTD Needs Catalogue. Some of these RTD priorities are addressed in national RTD programmes; however, a European forum for research programme planners to exchange experience and to co-ordinate their approaches on a European level has not so far existed. To initiate such a novel communication process between RTD programme planners in Europe, the Concerted Action CLARINET established a specific Working Group on “Co-ordination of RTD on a European level” (van Veen et al.).

The aims of this working group are:

- to survey currently funded research issues related to contaminated land and groundwater in the various RTD programmes in Europe;
- to initiate collaboration and co-ordination between RTD programme managers in the EU Member States, including the associated countries (e.g. Norway, Switzer-land).

National and EU Research Programmes

Research plays a central role in the implementation of public policy. In areas such as health, sustainable development and industrial, food and nuclear safety, policy options and decisions must be based on solid scientific knowledge and a comprehensive understanding of the environmental, economical and social aspects of the specific problems under discussion. Complex matters like sustainable land and water management require involvement of societal, economic and scientific stakeholders for integrative problem-solving approaches. In this regard, RTD programmes are an excellent instrument to facilitate the effective implementation of sustainable policies with all stakeholders involved (CARACAS/NICOLE 1997).

International co-operation in research would accelerate the development of an appropriate knowledge portfolio, which is needed to implement sustainable land and water management policies efficiently. The EU provides a legal basis to initiate suitable measures for international co-operation in research and technological development, but the principal reference framework for research activities in Europe is national. Co-operation among the national RTD programmes is an important condition for this acceleration of knowledge development. However, the analyses of national and EU programmes performed in the CLARINET RTD Working Group revealed that the current real-life management practice in the field of sustainable land management falls short of ideal practice.

Analysis of National and EU Research Programmes

The CLARINET RTD working group made an inventory of national and EU RTD programmes related to contaminated land and groundwater issues. Overall, eleven countries provided the requested information on their national research activities/programmes related to contaminated land.

Some major conclusions derived by the CLARINET RTD Working Group are as follows:

- The budgets of national RTD programmes in Europe add up to a total of about 20m Euro/year, and approx. half of that amount is added from the EU budget. Altogether, there are about 30m Euro/year available for contaminated land and groundwater research all over Europe. The costs for clean-up in Europe are estimated to be at least about 90bn Euro (EEA-ETC/S 1999). This means that the RTD effort for sustainable land management is less than 0.5%, considerably less than for other areas of environmental management.
- There is no co-ordination between national RTD programmes in Europe. The consequence is that all countries go through similar learning curves, resulting in a considerable overlap of research projects and targets. Up to now, there has also been a lack of co-ordination between national and EU research programmes. Overall, the missing co-ordination of RTD activities in Europe results in parallel expenditures and less efficient management of limited resources for European research.

- Almost all national RTD programmes are restricted to their own national research community and activities. Only a few countries provide certain funding possibilities for the exchange of experts with other countries, but real co-operation on a project level is rarely feasible. This means that cross-fertilisation and knowledge exchange among countries due to focused partnership projects is not available.
- The dissemination of achieved project results through national RTD programmes is very modest. The opportunities provided by the WWW are insufficiently used. The advantages of broad dissemination of project results at a European level have not been given particular consideration by most national RTD programmes so far. However, this situation is one of the main reasons for the creation of various contaminated land and groundwater networks in Europe over the past few years. One major aim of all these networks is 'to disseminate knowledge'. A co-ordinated approach by various European RTD programmes would be of substantial benefit in this regard.
- There is no co-ordinated approach in focusing the various RTD programmes in Europe towards the major gaps in scientific knowledge. The stakeholder networks CLARINET (regulators) and NICOLE (industry) have identified priority research issues needed to implement sustainable solutions for contaminated land and groundwater related problems in Europe (CARACAS/NICOLE 1997; Ferguson et al. 1998). So far, these research recommendations do not appear to be considered in the national research programmes.

As an overall conclusion enhanced co-ordination between countries' national research approaches will considerably increase the effects and yields of invested resources for focused scientific knowledge, which is urgently needed to meet the demands for sustainable solutions in Europe (Commission of the European Communities 2000).

Towards a European Research Area for Sustainable Land and Water Management

The CLARINET RTD Working Group recommends taking steps/establishing measures towards a co-ordinated European research policy on contaminated land and water management. Such a co-ordinated approach would be in line with recent EU recommendations for a future European research policy (Commission of the European Communities 2000). Some of these measures in accordance to these EU recommendations should be:

- A platform of research programme managers to exchange information on national research priorities, funding mechanisms and knowledge dissemination. The already established CLARINET RTD working group could be a suitable starting point for such a European platform.
- More coherent integration of national and European research activities. These could be achieved through a closer collaboration between various scientific and technological research organisations in Europe. The existing stakeholder networks such as NICOLE, CLARINET and ANCORE could provide a suitable platform to interlink and co-ordinate available resources and facilities towards a future 'research infrastructure' for contaminated land and groundwater at a European level. The involvement of various stakeholders in such a platform would enable far-reaching implementation of achieved research results into the formulation of problem-solving approaches.

- A joint approach to the needs and means of financing large research projects in Europe. For example, European researchers and technology developers could test and compare their products at specific demonstration sites in Europe.
- Better use of instruments and resources to encourage investment in research and innovation: systems of indirect aid (within the Community rules on state aid), patents, risk capital.
- Networking of existing centres of excellence and competence in Europe and the creation of virtual centres through the use of new interactive communication tools.
- More abundant and more mobile human resources:
  - increased mobility of researchers and introduction of a European dimension to scientific careers;
  - stimulating young academics for research careers in land and water management;
  - bringing together the scientific communities, companies and researchers of Western and Eastern Europe;
- Co-ordination of an agenda of joint research priorities and stimulation of transnational RTD projects;
- Stimulation of transdisciplinary research involving all stakeholders in the projects;
- More attention on the dissemination of knowledge in the national programmes. The focus should be shifted from pure knowledge supply to 'information on demand'.

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6 IMPROVED PROBLEM DEFINITION

6.1 HUMAN HEALTH AND ECOLOGICAL CONSIDERATIONS IN CONTAMINATED LAND MANAGEMENT

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Abstract

It is reviewed in which way the research needs as identified by CARACAS are filled in the Dutch work underpinning policy on contaminated soils. A change in focus from risk assessment towards sustainable land management can be descried. It is discussed which are the research needs to underpin a policy in this direction.

Introduction

Few years ago, the title of this presentation would probably have been 'Human and ecological considerations in risk assessment of contaminated land'. The focus on risk assessment is also reflected in the title of the 1998 CARACAS publication 'Risk Assessment for contaminated sites in Europe' (Ferguson et al., 1998). A change in focus from risk assessment towards land management is also found in Holland, although only the first steps have been undertaken in this direction.
What are the consequences of a focus towards land management for the scientific underpinning of policy? Which of the recommendations given by Ferguson et al. (1998) are also relevant for land management, and how have their recommendations already found their way in the scientific basis for the Dutch policy on contaminated soils?

Recommendations as Given by Ferguson et al., Are They Followed?

The recommendations as given by Ferguson et al. are summarised in Table 1. The same table lists if RIVM performed work in the past few years, as underpinning for the soil policy and under the authorisation of the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM).
Our work focused on the more concrete and technical subjects where further research was recommended. Much work is performed in the framework of the technical evaluation of the Dutch ‘Intervention Values’ (Lijzen et al., 2001). Lijzen et al. integrate underlying evaluations on human and ecotoxicological data, input data for the human exposure model CSOIL, and the evaluation of several exposure routes. They propose new risk limits indicating a serious soil, sediment or groundwater contamination. For these risk limits, both ecotoxicological and human toxicological considerations are taken into account although the levels of protection differ.
RIVM until now hardly paid attention to gamma-sciences related work as for example risk comparison and risk communication, in relation to contaminated soils. In the below there is a glance at part of our work related to contaminated soils. Several of the mentioned reports and articles are available via www.rivm.nl.

Models For Risk Assessment of Contaminated Soils

Probabilistic modelling has been in focus (e.g. Posthuma et al., in press; Van Wezel et al. 2000) in relation to environmental risk limits, although not yet applied in soil quality criteria as used for contaminated sites.
Methods related to spatial and temporal variation in soil quality are not used in soil policy until now, however in relation to biomagnification some discussion is going on right now.

Eco(toxico)logical Risk Assessment

Related to bioavailability work has been dedicated to a rapid and low-cost method for measuring freely dissolved contaminants, i.e. solid phase micro extraction or SPME. Bioavailability as measured by this method is compared with bioavailability of substances towards various species of worms (e.g. Jager et al., 2000). In this work also the role of organic carbon and selective feeding per species is taken into account. In addition, organism type and behaviour are studied as properties influencing bioavailability (e.g. Vijver et al., 2001).
Progress has been made in the use of bioassays. They are used in a TRIAD approach were information from chemical concentrations and thereby predicted affected part of the species, bioassays, and ecological observations on a site, are combined. This approach can be used by competent authorities to determine if there is an urgency for remediation of a site (e.g. Rutgers et al., 2000). In this type of work also information on life-support functions, for example via the PICT method, can be obtained.

Human Health Risk Assessment

Related to human exposure routes, the modelling on the exposure routes via plant uptake and via indoor air inhalation is improved. The relative contributions of exposure via contaminated soil compared to exposure via ambient air and food are studied. Both are reported in Lijzen et al., 2001, and are based on underlying reports respectively by Rikken et al. (2001) and by Baars et al. (2001).
Considering bioavailability of contaminants in soil for humans, and especially the bioaccessibility of soil contaminants in the gastro-intestinal tract compared with the accessibility of contaminants from the matrices normally used in toxicity tests, an in vitro digestion model is developed. In this model several metals and organic contaminants are tested, and the dependence of the bioaccessibility on concentration level, metal speciation, soil type etc. is subject of research (e.g. Oomen et al., 2000).

Contributions of CLARINET

For two of the mentioned topics in the above, under the wings of CLARINET international working groups have evolved. BARGE, the Bioavailability Research Group Europe focuses on various in vitro and in vivo systems to study boavailability of soil contaminants to humans. A round-robin study has already been performed, and clear ideas about the magnitude and also the reasons for differences between the various in vitro digestion systems are obtained. See for further information the contribution by Schelwald et al. in these proceedings. A comparable type of working group started this spring, related to the assessment of location specific ecological risks related to contaminated soils.

Table 1. Scientific and research needs as pointed out by Ferguson et al., 1998

No.	Subject	RIVM work
1	**Related to site investigation**	
1a	Robust and rapid low-cost techniques	✓
1b	Improved estimation and interpretation of the accuracy and variability	✓
1c	Methods related to spacial scales relevant for exposure	✓
1d	Biosensors and bioassays	✓
1e	Measure and model gas phase contaminants	✓
2	**Related to protection of water resources**	
2a	Macropore transport and fate of contaminants in soil	✓
2b	Organic carbon governing fate and transport	✓
2c	Assessment of potential for and monitoring of attenuation	✓
2d	Interactive metabolism of contaminants	✓
2e	Interaction and fate of mixtures	✓
2f	Free phase and it's transport	
3	**Bioavailability of contaminants in soil and groundwater**	
3a	Explicit consideration of biology of the organisms	✓
3b	Change of bioavailability in time	✓
4	**Human health risks**	
4a	Take into account relative risk contributions	✓
4b	Identify areas where better epidemiological and toxicological understanding can be achieved at a realistic cost	✓
4c	More consistent interpretation of toxicological and epidemiological data, dealing with the associate uncertainties	
4d	Better prediction by exposure models, specify human risks in space and time	✓
5	**Risk comparison**	
5a	Comparison with other type of risks, factors on which judgements depend	
5b	Valuation of risk (management), combining cost benefit methods with multicriteria decision methods	
6	**Ecological risk assessment**	
6a	Ecosystem theoretical framework for interpreting NOEC data	
6b	Ecological research on life support functions and groundwater ecology	✓
6c	Recovery at the site	!
6d	Ecological soil and groundwater quality requirements related to human landuse	!
7	**Models for risk assessment**	
7a	Field testing and validation	
7b	Accuracy of risk characterisation in view of effects observed in the field	
8	**Risk perception and communication**	

Relative Importance of Ecotoxicological Versus Human Toxicological Considerations in Risk Assessment

For most compound classes ecotoxicological risks determine the majority of the soil risk limits (Figure 1). Only for volatile compounds, human toxicological considerations are often more critical than ecotoxicological underpinned risk levels. For mineral oil components, no ecotoxicological risk assessment has been carried out yet. So in the Netherlands often the consideration of soil remediation starts when ecotoxicological risk levels are exceeded.

However, preliminary results of interviews with competent authorities (big cities and provinces) indicate that they give priority to the remediation of sites where human risk levels are exceeded. Some of them even state that remediation for reasons of ecology only have never occurred in their area of management (Roex & Vonk, unpublished results).

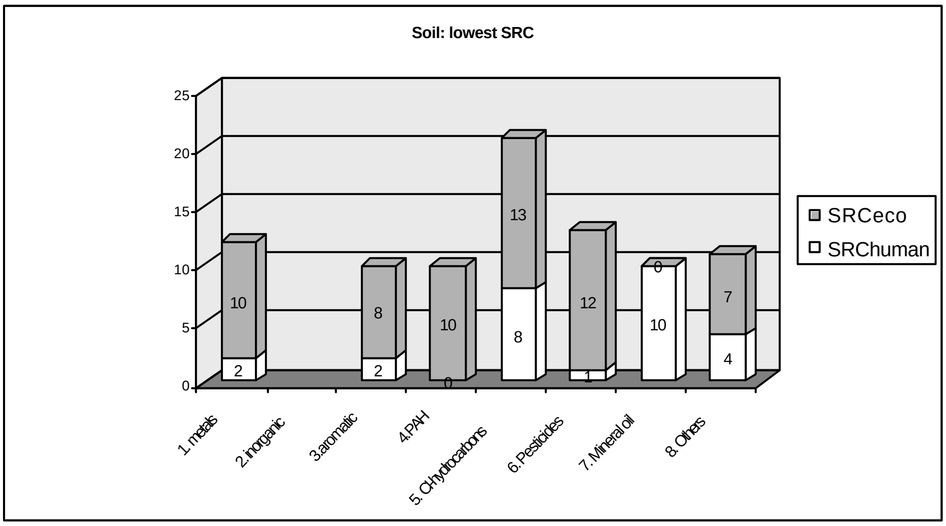

Figure 1: Most critical parameter (ecotoxicological risks versus human toxicological risks) determining proposals for soil quality criteria per compound class (Lijzen et al., 2001)

Land Management; Tuning Soil Use and Soil Quality

As described, little soil remediation is undertaken for reasons of ecological risks only; most remediations occur in the built-up area where human health risks are at issue. Therefore, in the rural area many serious contaminated areas have not been remediated and there is little support to do so in future.
Soil quality (chemical, physical and ecological quality) until now is not considered in spatial planning. There is a belief in technological solutions; 'every function can be realised anywhere'. Space is very intensely used in the Netherlands. Extra costs or losses due to an inappropriate quality are hardly considered. Therefore, soil policy wants to focus on a better fit between soil use and soil quality (figure 2, see also TCB 2000 and 2001).

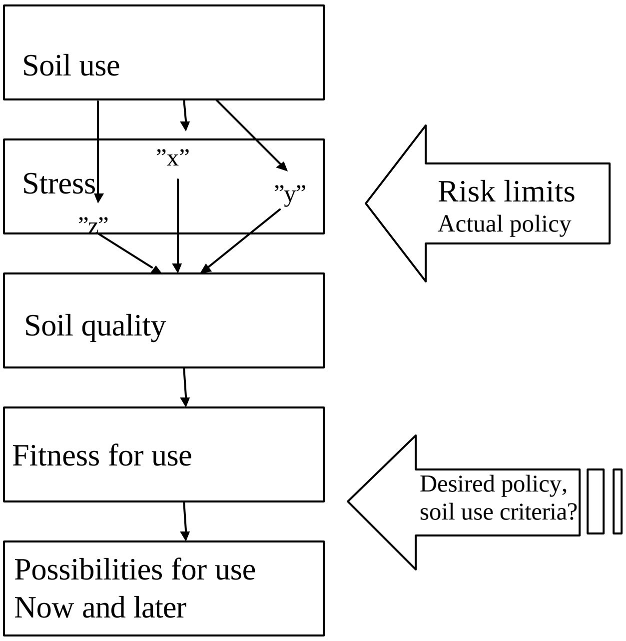

Figure 2: Current and desired policy on soils

For a scientific underpinning of this desired policy, several of the research needs as already pointed out by Ferguson et al. (1998) are of high relevance. Information on recovery at a disturbed site after a certain land-use is of importance, as we wish to avoid a restriction of land-use choices for future generations. Another relevant subject are the ecological soil and groundwater quality requirements related to human land-use. We will focus our future research to gain insight in the mutual relationship (so requirements and consequences) between land-use and soil quality. We'll kick off by clarifying relationships between soil ecology and agricultural land-use, as we have geo-information on both actual and historical land-use on a parcel level, and many soil ecological data.

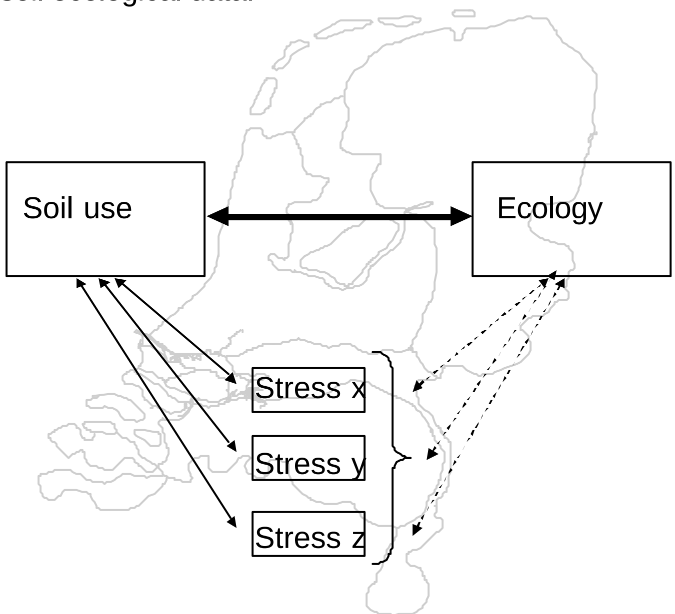

Figure 3: Scientific knowledge needed for the underpinning of desired soil policy

Conclusions

On many of the research needs as identified by Ferguson et al. (1998), results have been shown in past few years. Clarinet had clearly plaid a constructive role in the exchange of knowledge, and also actively put up international working groups on specific subjects.
In the near future, a shift in focus is expected from risk assessment towards sustainable land management. Here, much scientific work remains to be performed for underpinning the desired policy. An international network to exchange plans, ideas, knowledge, and to take common initiatives, will be very helpful in realising policy on sustainable land management in which soil use and soil quality are tuned.

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6.2 CALCULATION OF HUMAN EXPOSURE – AN INTERNATIONAL COMPARISON OF EXPOSURE MODEL VARIABILITY

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Abstract

The calculation of human exposure to contaminants can lead to a wide range of results, depending upon the model, parameters selected and model user. The consequences can be far-reaching. Therefore a better insight into the accuracy of exposure models is required. For this reason model calculations using different models from seven different European countries are compared. They are based on the same scenarios, with differences in soil use, soil type and contaminant used in the comparisons.

1. Introduction

The accuracy of human exposure calculations is limited because of uncertainties about model concepts and input parameters. However, human exposure models are in widespread use, both implicitly (comparison of measured contaminant concentrations with soil and groundwater quality standards based on these exposure models) and explicitly (decision-making based on site-specific exposure calculations). Therefore, a better insight into the accuracy of exposure models is required. This requirement can be most directly addressed by performing a validation study, i.e. comparing calculated exposure with measured exposure. However, measuring exposure in the human body is difficult, both for ethical and technical reasons. Another way to gain insight in model performance is to compare calculation results using different human exposure models, for standard datasets and assumptions.

The major aim of this comparative study, which is sponsored by the Dutch Ministry of Housing, Spatial Planning and the Environment (*VROM*), is:
Gaining insight into the variation in calculated human exposure.
Attention has been focused on the three major exposure pathways (*Van den Berg, 1991/1994/1995*): oral soil ingestion, crop consumption, inhalation of indoor air.

2. PROCEDURE

Recognising the value of a comparative study of human exposure models, a number of organisations involved with CLARINET and/or NICOLE have begun a collaborative study based on the human exposure models that they have been responsible for developing. They are (model given between brackets):

- *INERIS*, France (no name);
- *ANPA*, Italy (ROME);
- *VITO*, Flanders, Belgium (VlierHumaan);
- *RIVM*, the Netherlands (CSOIL);
- Kemakta Konsult AB, Sweden (no name);
- DHI Water and Environment, Denmark (CETOX-human) and
- LQM/ University of Nottingham, UK (CLEA).

Twenty hypothetical scenarios have been defined. These scenarios differ in respect to two land uses (residential and industrial), two soil types (sandy soil and clay soil), and five different contaminants. The contaminants (Benzo(a)pyrene, Cadmium, Atrazine, Benzene, and Trichloroethene) are from different groups, are considered to be common throughout Europe, and have different exposure characteristics.

All participants supplied the following data on the basis of a questionnaire:

- lifelong exposure and exposure to children and adults via the three major exposure pathways;
- lifelong exposure and exposure to children and adults via all exposure pathways combined;
- concentrations in contact media (pore water, soil air, root vegetables, "green" vegetables, indoor air).

There is an interaction between several outputs.
All exposure calculations have to be performed twice for all twenty scenarios:

- once with a prescribed set of parameters derived from the data set that was used to derive the Dutch soil quality standards *(Swartjes, 1999)*, but with the elimination of some typical Dutch features
- and once with the data that is used in different countries, i.e., each model's "own" default parameters.

For more detailed information on scenario's, definitions, models and input parameters, see *Swartjes and Boumans* (*in progress*).

3. Results / Conclusions

All participants conducted the calculations, which yielded a series of values for the seventeen outputs, for all twenty scenarios, once with the prescribed set of parameters, and once with the "own" default parameters. After reorganisation of the data the following actions has been undertaken:

- derivation and interpretation of "logical indexes", i.e. convenient measures that enables understanding, evaluating and communicating variations in calculated exposure;
- production of graphs, to enable visual interpretation; the major index presented in the graphs is *the relative deviation from scenario-averaged exposures (RD)*[8];
- ln-transformation and statistical analysis; the influence of the different variables on exposure has been investigated and confidence limits has been determined using the REML (Residual Maximal Likelihood) method (GenStat statistical package).

The results presented at this Conference will be focused on graphical results, supported by some statistical results. The calculation of exposure to children and adults, and hence lifelong exposure, is generally based on the same formulae and many input parameters are equal. Therefore only exposure to adults, which almost yielded a complete data set, has been analysed. At the symposium interpretation of the following results and conclusions will be facilitated by graphs.

[8]For each output there are 7 model results for 40 scenario's. The following two steps have been followed to yield the *relative deviation from the scenario-averaged exposures (RDs)* for each individual model result: i) calculate the average of each series of 7 model results; ii) divide each of the 7 individual model results by this average value. The resulting index, defined as *the relative deviation from the scenario-averaged exposures* (factor x higher, or factor y lower than the scenario average), enables comparison of variation in exposures between different scenario's, although absolute exposures might be of other orders of magnitude.

3.1. TOTAL EXPOSURE, ADULTS

Observations:
The majority of the RDs for *Total exposure adults* is between 0,001 and 10. This means that deviations are found from a factor of 1000 lower to a factor of 10 higher than the scenario-averages. Major variations are attributed to the calculation of exposure to Atrazine and lowest values for RDs can mainly be attributed to the performance of one specific model.

Estimations:
The influence of the variables on *Total exposure, adults* is decreasing in the following order: contaminant ≈ soil use > soil type > the combination of contaminant and soil use. The influence of choice of standardised versus "own" input parameters on *Total exposure, adults* is limited.
In table 1 the 95%-confidence limits for the median and the median values of *Total exposure, adults* are given for the five contaminants.

	2,5-percentile	Median	97,5-percentile
B(a)P	0,0307	0,152	0,751
Cadmium	0,0127	0,0627	0,310
Atrazine	0,0462	0,0244	1,29
Benzene	0,260	1,28	6,34
TCE	7,11	35,1	174

Table 1: 2,5- and 97,5-percentile (95%-confidence limits) and median values ($ng/kg_{body\ weight}/day$) for the five contaminants

3.2. Exposure Major Exposure Pathways

- For *Exposure due to Ingestion, adults* most of the RDs are close to 1. This means calculated exposures are close to the scenario-averages. A small cluster of RDs is around 0,001, which is attributed to one specific model (but another model that causes the low RDs for *Total exposure, adult*). Besides, the calculation of exposure to Cadmium gives rise to some small RDs.
- For *Exposure due to crop consumption, adults* most of the RDs are between 0,1 and 10. This means that deviations are found from a factor of 10 lower to a factor of 10 higher than the scenario-averages. There is no clear influence of choise of contaminant on RDs, only calculation of exposure to B(a)P gives rise to some small RDs.
- For *Exposure due to indoor air inhalation, adults* most RDs are more or less homogeneously distributed between 0,001 and 10. This means that most of the deviations are in the range of a factor of 1000 lower to a factor of 10 higher than the scenario-averages. A small cluster of RDs is between 0,001 and 0,00001. Major variations (including low RDs) can be attributed to the calculation of exposure to Atrazine and (to a lesser extent) to B(a)P (absolute values of exposure due to indoor air inhalation for these contaminants is low). Influence of choise of model on variation in *Exposure due to indoor air inhalation, adults* is sustainable, but relatively consequent (a specific model calculates relative high or low exposures for most scenario's).

3.3. GENERAL RESULTS

- There is no clear influence from using standardised or “own” input parameters on the variation in exposure.
- There is a trend in model performance in relation to variation in exposure: for each model, variation in RDs is in general limited for a specific exposure.
- There is no clear difference between RDs for residential versus industrial sites, neither for sandy soil versus clay soil. This means that variation in exposures is not much influenced by soil use or soil type (although absolute exposures can differ substantially). The impact of choise of model and contaminant on variation in exposure is much more evident.
- Possibly differences in model performance can be attributed to “misunderstandings”, i.e. differences in interpretation in definitions of outputs and scenario’s.

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6.3 HUMAN BIOAVIALABILITY OF CONTAMINANTS OF INGESTED SOIL – BARGE PROJECT

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Introduction

BARGE is a European network organisation bringing together institutes and research groups to study the human bioavailability of priority contaminants, such as lead, cadmium and arsenic in soil via the gastro-intestinal tract. The correct estimation of this bioavailability may have a major impact on current risk assessment practice. The first goal of BARGE is to compare and evaluate the many models and systems that have been developed over the years to estimate bioavailability and contaminant exposure. The ultimate goal is a methodology to arrive at more realistic bioavailability factors to be used in site specific risk assessment and for policy making.

Project Description

In the field of human risk assessments soil ingestion is in most cases the dominant exposure route for immobile contaminants in soil. In the absence of more detailed information, the default value used for relative oral bioavailability is commonly 100 %. This default value is used in most guideline values (trigger values, intervention values, soil screening levels, etc.). This assumption has an impact on soil clean-up values, soil management and policy on risk assessment in general. However, it is widely believed that most contaminants ingested in a soil matrix are likely to be less bio-accessible (i.e. extractable in the human gut) than in the material used in past studies that was used to derive tolerable daily intakes. A more realistic value and approach has important economic consequences.

Within Europe and abroad much valuable research is being done on examining the bioavailability of contaminated soil after ingestion by humans, and in particular by children (the high-risk group). However, most researchers focus on different aspects of the problems related to human bioavailability and therefore, just a part of the 'solution'. **Co-ordinating efforts** and **pooling present and future available** knowledge and expertise to achieve an overall picture can obtain added value. Such pooling may result in more realistic bioavailability factors and as a consequence, more realistic exposure calculations. This is particularly important for priority contaminants like lead, arsenic and polyaromatic hydrocarbons.

The idea that extra attention should be paid to this topic was raised at a CLARINET meeting (Contaminated Land Rehabilitation Network for Environmental Technologies) in November, 1998. It was concluded at this meeting that more realistic factors for human bioavailability of contaminants ingested with soil were needed. More precise knowledge on the bioavailability of ingested soils could have a major impact on risk assessment practice. It could also greatly reduce the costs of dealing with contaminated sites in all CLARINET countries. R&D co-operation between experts working on this topic seems an efficient way to enhance the knowledge in this field within the next few years.

Research Status Quo

In December 1999 the Dutch ministry of VROM (Ministry of Housing, Planning and the Environment) decided to finance an investigation into possible European co-operation in this field. A separate, external body (Schelwald-van der Kley Consulting B.V.) was commissioned to discover and describe the status quo in the field of human bioavailability, by means of a questionnaire, interviews and Internet search. In addition, the need for co-operation and/or exchange of data was investigated in a feasibility study. The need for co-operation appeared to be strong and a great enthusiasm to exchange knowledge between countries was evident. Even before the study made its final report, a workshop had been organised for researchers to meet each other and discuss the way forward. The results of this workshop were included in the final report of the feasibility study, "Human bioavailability of contaminants in ingested soil: A. Feasibility study on R&D co-operation; B. Set up and first results of collaborative R&D" (VROM/TCB), June 2000.

The participants in this workshop agreed to compare and validate current test systems using identical soil samples. In addition it was decided to continue with this initiative and so BARGE (Bioavailability Research Group Europe) was established. The tests mentioned above were conducted during summer 2000. Preliminary results have been discussed and a number of research questions have been defined. The first test results revealed great diversity in bioavailability factors for similar soil samples, strengthening the need for greater understanding of the driving forces behind these differences (*www.schelwald.nl/pages/barge)*.

Recently NICOLE[9] and CLARINET issued a Joint Statement on Sustainable Management of Contaminated Land, in which they mentioned assessment of bioavailability as a key research need. The EU has also designated bioavailability in its broadest sense as a key topic in its 5th Framework Programme.

Funding

So far, BARGE has been self-funding. However, taking into account the limited budgets of the research organisations contributing, external financing of further research work and information exchange is urgently needed. Considering the collective importance and value of the deliverables for all EU-countries, an appeal is made to Ministries and Environmental Agencies of the CLARINET countries to sponsor further BARGE activities. Counting on at least 8 countries to contribute, a financial contribution of 25.000 - 40.000 Euro (depending on the involvement) is needed per individual sponsor for a period of 2 years. This money is mainly intended for actual collaborative research activities. The EU-COST programme has been asked to become sponsor through an additional 65.000 EURO per annum, which is needed for organisation of meetings and the subsistence costs of research participants. Meanwhile a proposal will be made for the EU 5th Framework Programme for longer-term research work.

Future Plans

A major goal for the next 2 years is to arrive at a cost-effective assessment method to estimate human bioavailability for the priority contaminants lead, cadmium and

[9] NICOLE: Network for Industrially Contaminated Land in Europe

arsenic. The focus will be on the correct estimation of bio-accessibility[10], a major factor in determining overall bioavailability.
To meet this goal a number of activities are foreseen:

1) A brainstorming meeting (early 2001) with all sponsors and research participants with the aim of defining the most important policy issues regarding bioavailability and resulting research questions;
2) In-depth comparison and validation of the different national test methods available. This will include research into the influence of variability between test parameters on test results, resulting in a proposal of which method to use in what circumstances; this may lead to one (or more) commonly accepted method(s);
3) Estimation of bioavailability for a number of selected soils from 'real life' case studies in different EU-countries;
4) Regular meetings with research participants to discuss progress and exchange information;
5) A final workshop in early 2003 with all sponsors to discuss the findings.

Another major project deliverable will be a draft framework providing policy guidelines on how to assess bioavailability in risk assessment practice.

Your Contribution?

If you are interested in this important issue or would like to become a sponsor we kindly ask you to contact the BARGE secretariat by mail to barge@schelwald.nl; they will contact you to discuss your interests in more detail.
More information can be found at the BARGE web pages at *www.schelwald.nl/pages/barge.*

[10] Bioaccessibility is defined as the fraction of a substance that is released from the soil matrix in the human gastro-intestinal tract and is available for absorption.

6.4 RESEARCH ISSUES FOR THE ENVIRONMENTAL EPIDEMIOLOGY OF CONTAMINATED LAND

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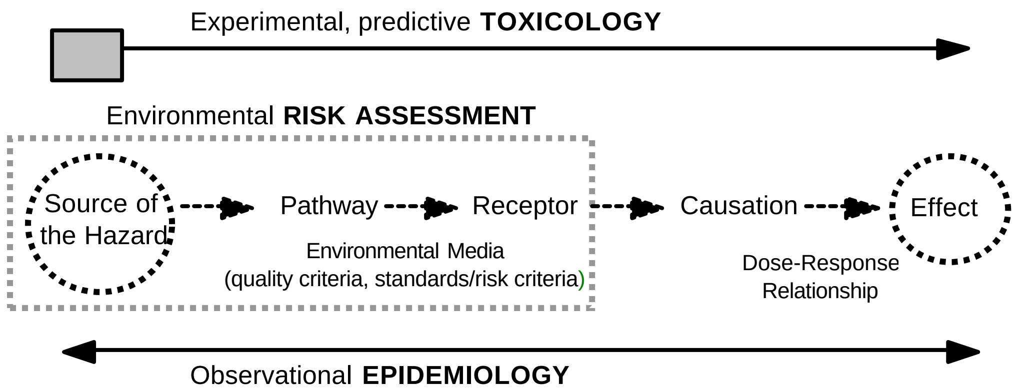
Abstract

Issues of research and practical implementation associated with the use of environmental epidemiology tools for land contamination problems are summarised. These were identified during a joint workshop between the Environment Agency of England and Wales and the European Commission Concerted Action "CLARINET", (Working Group 6) convened in March 2001.

Introduction

Environmental exposure assessment is an important analytical tool for evaluating the likelihood and extent of actual or potential exposure of receptors to the sources of environmental hazards (Ferguson *et al.*, 1998; Paustenbach, 2000). Examining the *causality* of adverse effects, however, requires closer attention to the mechanisms of toxicological action and a statistical analysis of effects by reference to the potential source of the hazard (Figure 1). Environmental epidemiology supports this type of analysis.

Figure 1 Causal chain model for environmental health risks (after Thomas and Hrudey, 1997).



1. Types of Epidemiological Tools and Techniques

Types of non-experimental (observational) epidemiological studies include ecological, cross-sectional, cohort and case-control studies. Ecological studies focus on the comparison of groups while the other three collect data on individuals. Ecological studies include geographical studies of spatial patterns and time trend studies. Here, the relationship between the spatial patterns of exposure (for example region, work-site or school) and disease are described. Time trend studies assess the association between changes over time of exposure and disease. The main advantages and weaknesses of ecological studies are summarised below (Table 1).

Table 1 Observational, ecological studies: advantages and weaknesses

Advantages	Weaknesses
• Relatively inexpensive and takes little time (duration of study) • Makes use of available secondary data sources • Overcomes problems of being unable to measure accurate individual exposure • Provides useful output for informing policy and decision making • Generates hypotheses about aetiology of disease	• Ecological bias, that is the failure of ecological effect estimates to reflect the true effect at the individual level • Secondary sources of data from different areas or time periods may not be strictly comparable • Cannot always be confident that disease occurrence did not precede exposure • Collinearity: some socio-demographic and environmental variables are more highly correlated with each other at the group level than they are at the individual level

Cross-sectional studies provide a "snapshot" of exposure and disease occurrence at a particular point in time. Cohort (or prospective) studies follow up a group of people with a particular exposure and compare disease occurrence with that in a group without the exposure. All epidemiological studies have uncertainties associated with them and their statistical power can be severely constrained with respect to environmental exposures.

2. Application to Soil Contamination Problems

A range of human health assessment tools has been applied to soil contamination problems. The workshop considered case studies of regional arsenic exposure (Farago *et al*., 1997) and localised cadmium exposure (Järup *et al*., 1998) to examine (a) the appropriate tools and technique(s) available; (b) the challenges/ uncertainties and limitations of the technique(s) chosen (Table 2); and (c) the expertise and organisations that should become involved in a study.

3. Conclusions

Two recurrent themes in our discussions were: (i) When should an epidemiological study be carried out?; and (ii) Is it possible to establish a statistical link between cause and effects (taking into account mixtures, lack of dose-response data and relatively low levels of exposure generally encountered in environmental epidemiology studies)?

Table 2 Approaches to solving a regional issue of arsenic land contamination

Approach	Advantages	6.5 CHALLENGES	Limitations
Detailed exposure assessment	Not reliant on latency of effects, thus allows for quicker policy decisions; can focus on resolving key uncertainties; pilot biomarker study offers biological plausibility for a detailed study	Need to account for dynamics of exposure; and temporal and spatial aspects (residence time in area), heterogeneity of As concentrations in soils and dust; vulnerable (sub)-populations	Adopt dose-response relationships from similar studies; problems of low-dose extrapolation; bioavailability unlikely to be resolved within time frame of study
Health surveillance	Relatively inexpensive; possibility of existing records; may help to identify clusters of highest exposure, sensitive to local effects; could be supplemented with a questionnaire	Detection and attribution. No systematic reporting of potential effects from chronic arsenic exposure; issue of training health professionals in signs of disease/exposure	Anecdotal evidence of low health status of receptors only; little direct evidence; long latency period for some health effects; not suitable for establishing causality

Table 1 (cont'd)

Approach	Advantages	6.6 CHALLENGES	Limitations
Historical, retrospective cohort study	Objective to establish causality	Issue of population migration into and out of study area confounds ability to establish a static population and suitable case control; potential for study to underestimate the risk (non-differential miscalculation)	Requires large study numbers to afford suitable resolving power; long latency period or some effects of chronic arsenic exposure, vulnerable population; confounding factor of radon exposure; high cost

The workshop reported (EA and CLARINET, 2001) on practical issues of using epidemiological tools and noted some key characteristics of environmental epidemiological studies (Berglund *et al.*, *in press*):

- the statistical power of many environmental epidemiology studies may not be sufficient to draw meaningful conclusions regarding specific sources of exposure - studies require good exposure assessment to support them;
- exposures are often commonly occurring, but not specific;
- there is usually a limited range of exposures, that is “high exposure” is not very different from “low exposure”;
- there are often multiple exposures (complex mixtures) but usually, exposure to single compounds only is included;
- individual exposure data are often lacking, group- or community-based data may be poorer surrogates; and surrogate data (for example pollutant concentration in soil) may be invalid, unless a complete exposure pathway can be demonstrated;
- large populations are often exposed, and therefore the impact of relatively low risk excesses may be important.

Research issues identified at the workshop included:

1. The need for improved interfaces between (i) environmental exposure assessment and epidemiology; and (ii) scientific study using human health tools and techniques and decision-making processes.
2. The relative value of surrogates for exposure needs to be evaluated.
3. Practical mechanisms for collating and integrating common data sets of use to exposure assessors and epidemiologists are required.
4. More effort on the detection and attribution of chronic health effects and those resulting from intermittent exposures is needed.
5. Information on the minimum data set requirements for epidemiological studies would be valuable.

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6.5 ECOLOGICAL RISK ASSESSMENT FOR CONTAMINATED SITES IN EUROPE – ECORISK CONCLUSIONS

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Abstract

The workshop on ecological risk Assessment (ERA) in Nunspeet, The Netherlands (17-19 April 2001) was an initiative of the CLARINET ecology working group. Aim of the workshop was to discuss the scientific developments and policy needs on **site-specific ecological risk assessment** and to come to a proposal for an European-framework for site-specific risk assessment. An important conclusion is that a framework is much demanded. A procedural framework provides uniformity and gives quality insurance. On the one hand there is agreement on the outline of an European-framework on site-specific ecological risk assessment. On the other hand many details are not filled in yet or have not been discussed. From these two facts it can be concluded that a common framework for ERA is feasible and desirable, but that an ongoing discussion is required to fill in the details.

Introduction

The workshop on Ecological Risk Assessment (ERA) was an initiative of the ecology working group of CLARINET. Aim of the workshop was to recognise and discuss the scientific developments, tools available and policy needs on site-specific ecological risk assessment and to combine these aspects into a proposal for an European framework for site-specific ecological risk assessment. Another goal was to identify the gaps and needs for future development in this area. Prior to this workshop a questionnaire had been held among all country representatives of CLARINET. By means of this questionnaire the European-use and needs for ecological risk assessment were listed.

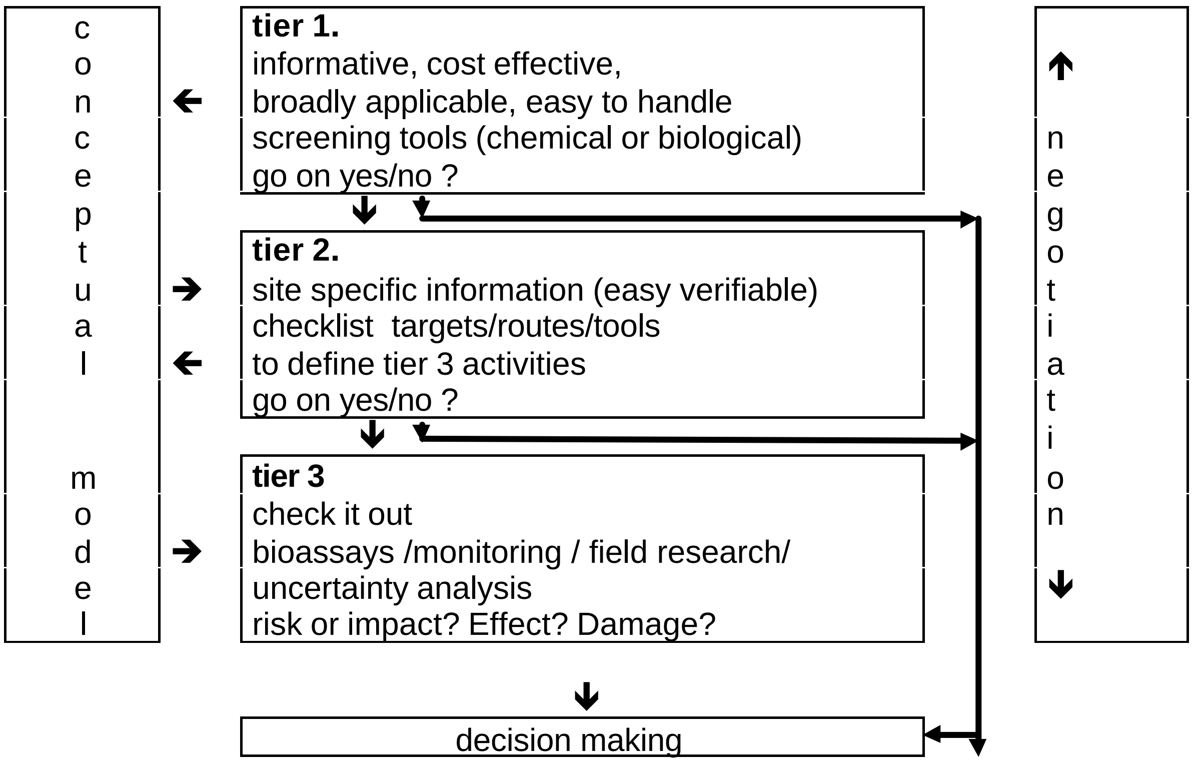
Organisation of the Workshop

The idea for a workshop was born at the CLARINET meeting in Dublin October 1999. After discussing the outline of the workshop in Helsinki, March 2000, a questionnaire was set-up. The results were discussed at the CLARINET-meeting in Venice, October 2000. Results indicated that most respondents use or intend to use some kind of ecological reasoning in generic guidelines and/or site-specific assessments. In general, information on plants, soil fauna, micro-organisms and processes is included. There exist several uncertainties in ERA such as extrapolation from “lab to field”, non-homogeneity among test conditions, unreliability of models, controversies between opinions of experts and lack of basic knowledge on soil biota. From the results of the questionnaire it could be concluded that there appears to be a need for a common European site-specific ERA approach and it was decided to organise a workshop in spring 2001 on ERA in the Netherlands. The organising committee set-up the programme and list of participants in a meeting in Leiden in December 2000.

Outline of Framework on Site Specific Ecological Risk Assessment

All participants of the workshop agreed that a framework is needed. The framework should provide a decision-oriented approach based on the application of scientific knowledge. A conceptual model, describing the potential threats, exposure routes and impacted ecological targets, is considered as an important aspect of the framework. When applying ERA, one should consider the size and the ecological value of the location, the long term planning and the surrounding environment (there may be off-site transfer and receptors may move in). Bioavailability of contaminants should be incorporated (data on contaminant characteristics, soil characteristics, biota). Whether groundwater and its ecological receptors should be included in an ERA remains open for debate. According to some participants the position of groundwater an its ecological receptors in ERA is not well established and therefore precaution should be taken!

At the basis of each ERA historical research should be carried out (which pollutants, which comparable accidents are known etc.). After that a tiered approach can be followed, presented in the table below:



Conclusions

All participants agreed that a framework is required to structure the process of the risk assessment. A procedural framework will give guidance to perform an ERA uniformly and quality can be assured. The common framework should be flexible, so that country specific details can be built in. The approach should be tiered and decision oriented. It is recommended to keep things simple. Make a management tool (framework) for contamination which can be used for a comprehensive ecological risk assessment including all stresses and ecological requirements for various land-uses and functions (ecological aspects in a suitability for use approach).

Bio-assays and biological field data are considered important additional tools in ERA. There are already some OECD and ISO bio-assay standards which can be used in ERA. There are many other tests available depending on site and ecological targets which are currently not under OECD and ISO regime, but still useful in ERA. Promising methods with a potentially wide application range should be urgently validated.

It is recognised that convincing the landowner to use ERA is a bigger problem than ERA itself. Public communication is considered important because the public perception of risk is crucial to the final approval of ERA. A scheme for interpretation of results from the different tools in terms of ecological impact is important and lacking at the moment.

Overall it can be concluded that a common framework for ERA is feasible and desirable, but that an ongoing discussion is required to fill in the details on how one should perform a site-specific ERA. Besides this it should be discussed how future development will be organised. From these conclusions it was recommended:

1. To erect the European framework for ecological risk assessment as soon as possible in a task force group
2. to promote discussions between European partners on parts of the framework and details by means of networking and meetings
3. to demonstrate and advocate ERA by pilots executed by an European consortium

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7 SUSTAINABLE SOLUTIONS FOR CONTAMINATED LAND RISK MANAGEMENT

PART 1: TECHNICAL OVERVIEW OF THE CURRENT STATE OF THE ART

7.1 SUMMARY OF CLARINET`S KEY FINDINGS ON RISK MANAGEMENT SOLUTIONS AND DECISION SUPPORT IN EUROPE

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Abstract

This summary outlines the key findings of WG2 and WG7 as of May 2001. More detailed information will be made available at the session.

This paper is organised in two parts:
- Executive Summary for WG2, and
- Executive Summary for WG7

Decision Support for Management of Contaminated Sites in Europe

Introduction

Decision support exists to help those who have to take decisions deal with the complex and wide-ranging information involved in contaminated land management. Decision support can be provided as written guidance (flow sheets, model procedures) and/or software. It aims not only to facilitate decision making but to help ensure that the process is transparent, documented, reproducible and hopefully robust, providing a coherent framework to explore the options available. The need for decision support is widely recognised and in recent years a large number of decision support tools (DSTs) have been developed, with varying degrees of success in practical use. They use these to identify the range of options for solutions that best fit the constraints of the problem they are addressing.

The Activities of Working Group 2

CLARINET through its Working Group 2 *Decision Support* (WG2) has surveyed decision support issues in 15 countries, taking part in CLARINET. The following countries contributed to the survey: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain (*Catalunya only*), Switzerland and the United Kingdom. This survey was based on the use of questionnaires circulated to CLARINET national representatives. The responses to these questionnaires have been compiled and peer reviewed, and will be made available in the WG2 Final Report. They have also been used as the basis for a WG2 suggestion for categorising and describing decision support approaches outlined below. The DSTs identified have been used in a prototype catalogue for DSTs, which is to be linked to the CLARINET web site in 2001 (www.clarinet.at). The Final Report for WG2 (Bardos *et al* 2001) will also be available from this web site.

Describing Decision Support

The decision making process for any problem usually encompasses:
1. An identification phase in which the problem is identified
2. A development phase in which possible solutions are identified and developed
3. A selection phase in which the solution to be implemented is chosen.

Decision Support is the assistance for, and substantiation and corroboration of, an act or result of deciding; typically this deciding will be a determination of optimal or best approach. Several "layers" of decision support can be distinguished: the input information, tools to assist particular decision making issues, and the overall system in which decision making is applied.

Decision support codifies specialist expertise in a way that allows its reproducible use by many. It integrates specific information about a site and general information such as legislation, guidelines and know-how, to produce decision-making knowledge in a way that is transparent consistent and reproducible.

The wide range of existing DS vary from simple diagrams derived from standards or regulations, to software based systems. Globally speaking, applications have been developed for most of the contaminated site management, from the characterisation of contamination and risk assessment phases, through risk management to the aftercare and monitoring. In the context of contaminated land management, WG2 has been using a simple framework to classify DSTs based on four types of category:

Functional application	Decision Making role
Analyses used	Nature of the product

These are set out in more detail in Tables 1 to 4 below.

The Stakeholders in Decision Making

The principal stakeholders in land remediation are typically the "problem owner" (usually the polluter or site owner), the "regfulator" and the "solution provider. However, other actors are also likely to have a legitimate interest in many remediation projects and its redevelopment, and the environmental, social and financial impacts of any necessary risk management works. Depending on the size and prominence of the site these stakeholders can include several of the following:

- Land owners / problem holders;
- Regulatory and planning authorities;
- Site users, workers, visitors;
- Financial community (banks, funders, lenders, insurers);
- Site neighbours (tenants, dwellers, visitors);
- Campaigning organisations and local pressure groups;

- Consultants, contractors and technology vendors; and possibly
- Researchers (in some circumstances).

Each will have their own perspective, priorities, concerns and ambitions regarding any particular site. The most appropriate remedial actions are likely to be those which offer a balance between meeting as many needs as possible, including also the need to protect the environment, without unfairly disadvantaging any individual stakeholder.

Key Conclusions

To be drafted:

availability of DST and their usefulness

availability of decision support information and the work of WG2

gaps in provision

suggestions for future tasks

Table 1: Functional Application (Examples)

The functional application to contaminated land management describes whether the decision support is for risk management, remediation, monitoring and aftercare, sustainable development etc. This deals with the issues that must be addressed to support the overarching decision. In practice, a number of DSTs address multiple decision criteria.	• **Problem Identification** • **Site investigation** • **Risk assessment** • **Risk Management** • **Aftercare** • **Monitoring** • **Evaluating Wider Impacts (environmental economic etc)** • Sustainability appraisal

Table 2 Decision Making Role(Examples)

The decision making role describes the type of decision making being supported, e.g. for managing a single site, or for prioritising a number of sites. This deals with the overarching decision being made at the site.	• **Identification - of problem sites**
	• Prioritisation
	• Comparison - of options
	• **Strategy development**
	    • **policy**
	    • site specific

Table 3 Nature of the Product (Examples)

The nature of the product describes whether the tool is written guidance; a "map" of some sort, a series of procedures or a software based system.	• Software system • Written guidance • Flow charts • "Model" procedures • Protocols

Table 4 Analyses Used (Examples)

Several different techniques can be employed to assist environmental decision-making. In practice, many decision support tools use several of these techniques, or mixtures of different parts of them. For example, software tools might combine risk assessment and cost-benefit analysis techniques to generate risk maps, cost comparisons between remedial options and other decision information.	• **Cost benefit** • **Life Cycle** • **Protocol** • **Multi-criteria analysis** • **Risk Assessment** • Sustainability appraisal

Remediation Technology in Europe

Introduction

Several billion EURO are spent in the EU each year on the remediation of land affected by contamination. It is an important goal from all perspectives that this money is spent wisely and appropriately. A risk based decision making process for remediation is now the norm across EU Member States (CLARINET and NICOLE, 1998). In this process, risk assessment and the subsequent step of risk management are intimately related elements that form the basis for a fitness-for-use approach to land affected by contamination. Risk assessment was the focus of CARACAS, the Concerted Action which was a forerunner of CLARINET (Ferguson *et al* 1998, Ferguson and Kasamas, 1999).

CLARINET through its Working Group 7 Remediation Technology (WG 7) has surveyed state-of-the-art of implemented remediation technology in the European countries represented in CLARINET. The survey was based on the use of questionnaires circulated to CLARINET's national country representatives. The responses to these questionnaires have been compiled and peer reviewed, and will be available through the WG 7 Final Report. This will be made available from CLARINET's Web side in 2001 (www.clarinet.at).

The WG 7 report presents a State-Of-the Art (SOA) review of implementation of remediation technologies in the different European countries. It comprises a description of the key elements for describing and selecting remediation technologies, and their principle categories (which are outlined in the next paper of this session). It goes on to provide a detailed inventory, by country, of technology development programmes, pilot scale projects and the use of remediation technologies. As remediation technology is an extensive topic, these country reviews are by necessity overviews. Further information can be obtained by referring to the existing national documents provided for each country, and the references given in the document.

Pilot Scale Technology Development Programmes In Europe

A range of pilot scale studies and demonstration programmes are ongoing in Europe. Some of the programs are international with partners from outside Europe.

One major international programme is the NATO/CCMS pilot study. In this programme a broad range of countries have been and are demonstrating different technologies. The study covers a broad range of technologies such as remediation of gasoline, phenol, tar, BTEX, metals etc. in different media. The results are reported and discussed in an international context. The study is now in the third phase with demonstrations of 15 different technologies from 10 different countries. The earlier phases have been reported both in paper (EPA/542/R-98/002) and electronic format (http://www.nato.int/ccms/pilot-studies/pilot007/).

The other major programmes include the TUP programme sponsored by the Danish EPA, 4-5 years programme “Tests of polluted soil treatment and technology development” initiated 1998 by ADEME in France, the Dutch NOBIS programme (SKB), the German VEGAS programme, the British CL:AIRE and exSite programmes, and the Swedish Coldrem programme.

State-Of-The Art Of Technology Implemented In Europe

The future use of land, and the money available for developing this use, are powerful controlling influences on the nature of remediation technologies that can be used. There is a constant pressure for lower remediation costs, both to improve the economics of brownfield re-use for "hard applications" such as housing or commerce; and for "softer" uses such as nonfood agriculture. There is growing pressure to develop more cost-effective remediation technologies. Cost effectiveness is not just a product of reducing remediation costs, but also of inding remediation approaches that provide an additional enhancement to the value of the land.

The highest cost reducing potential can be achieved by reducing the volume of soil needing treatment and by increasing the proportion of materials to be recycled and reused. Experienced and professional project management, relevant and adequate site investigations, improved knowledge of the performance and efficiency of remediation processes can significantly enhance the accuracy of forecasting remediation costs. This information needs to be addressed not only from “problem definition” or “solution provision” perspectives, but as interdependent issues. For example, appropriate site investigation not only highlights problems, it also acts as a guide to the solution. Inappropriate site investigation does neither. All procurement of services needs to be done with a view to value, not cost. In current terms this is “intelligent procurement”, concentrating on value and confidence in achievement of objectives.

There are two further factors that impact on the cost-effectiveness of remediation technologies that are outside the remit of most CLARINET participants. The first is the impact of waste legislation and regulation that, in certain nations, determines the fate of contaminated soil, and the potential for its treatment, disposal, recovery, recycling and reuse. The second is the designated land-use of a remediated site; this has a profound effect on site values and hence the options available for remediation.

In general, concerns over feasibility tend to be greater for innovative remedial approaches, even if these have long standing track records in other countries. However, it is often these innovative solutions that are seen to offer more in terms of reducing wider environmental impacts and furthering the cause of sustainable development.

Ex situ technologies are by far, the most, used technologies in Europe.

In situ technologies are currently in the early stage of implementation in Europe, and a number of constraints must be resolved before they are readily implemented. Assuming that a remedial approach can be adequately monitored and controlled, there is an increasing desire to promote in situ over ex situ solutions and on site solutions over solutions based on removal off site. However, there are often conflicting pressures affecting whether or not an on-site or off-site approach is taken. In some cases stakeholders may express a preference for a solution based on removing materials off site. This may be related to concerns over residual liabilities, which in turn are related to concerns over the duration, feasibility or completeness of on site solutions. Conversely, removal of materials off site may be problematic because of the transportation and related problems, or because excavation is not considered technically or economically feasible. Offering previously validated solutions and developing an appropriate verification strategy for the sites in question are key steps in dealing with these concerns.

The table below demonstrates, however, that in situ technologies are in the stage of being fully accepted throughout Europe.

There is currently great interest in Europe in promoting greater consideration of the principles of sustainability in remediation work. Different countries are using different approaches to measure sustainability. There is a need to develop these further towards a harmonised approach. The Danish EU Life project has developed a methodology that includes the total environmental costs and benefits as decision parameter- together with traditional parameters, such as time, finances and function (Scanrail 2000). When side effects of remediation technologies are taken into consideration, the decision of technology could be different.

State of the art of implementation of in situ technologies in Europe.

In situ Technology	Scale and degree of implementation			
	R&D	**Pilot**	**Demonstration**	**Commercial/full scale**
Bioventing	DK, NL, UK		DK, SF	DK, B, F, G, EI, I, N, UK
Soil Vapor Extraction (SVE)	DK, NL	UK, F, A	DK, D	DK, B, F, SF, G, EI, I, N, E, S, UK
Air sparging/biosparging	NL, UK		DK	DK, B, F, EI, I, N, S, UK
Dual phase extraction				DK, NL, F, EI, I, UK
Bioslurping			NL, D, A	EI
Steam stripping		D	DK	DK, NL, F, SF
Biostimulation	DK, NL, D, A, UK	DK, NL, D, A	NL, D, A	D, B, SF, EI, N, CH, UK
HRC				DK
ORC	UK	DK, D, EI		DK, UK
Soil washing/flushing	UK	D, I		DK, F, G, UK
Electro kinetics	DK, NL,UK	DK, NL, SF	DK, NL, S	D, NL, F
Electrical heating		DK		
Phytoextraction	DK, NL, B, UK, F, D	DK, F, B, SF, UK, EI	DK, UK	F, EI
Phytostabilization	DK, NL,UK		DK	
Permeable Reactive Barriers (PRB)	DK, D, UK, A	D, NL, SF, G	DK, D, NL, I	DK, D, F, EI, CH, UK
Encapsulation/containment	D	D, A	D, E	DK, D, F, B, SF, EI, I, E, CH, UK
Solidification	UK	UK, EI	UK	D, SF, G, UK
Stabilisation/stabilisation	UK	D, F, A, B, G, EI	NL, I, UK	D, B, F, SF, G, UK
Biostabilisation	D			
Chemical oxidation	DK, D, SF	F, I, EI	DK, S	DK, D, EI, N, UK
Thermal desorption			DK	F, UK
Hydraulic fracturing	DK		DK	D, UK AVAILABLE
Hydraulic containment	UK			UK
P&T	DK, NL, D, UK		DK	DK, D, B, SF, EI, S, CH, UK
Monitored Natural Attenuation (MNA)	DK, D, NL,	UK, A, EI	DK, NL, I	DK, NL, F, EI, S, UK

Acknowledgements

The many contributions from the members and contributors to WG2 and WG7 are gratefully acknowledged (see following Annexes).

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7.2 A FRAMEWORK FOR SELECTING REMEDATION TECHNOLOGIES FOR CONTAMINATED SITES

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Abstract

A risk-based approach to contaminated land management has been adopted in many European countries based on the pollutant linkage paradigm. Six key sets of factors can be distinguished for the selection of an optimal risk management solution: the drivers and goals for the remediation project concerned, risk management, sustainable development, stakeholders' (third party) views and technical feasibility and suitability.

Introduction

There are a number of factors that need to be considered in selecting an effective remediation solution. These include considerations of core objectives such as risk management, technical practicability, feasibility, cost/benefit ratio and wider environmental, social and economic impacts. In addition, it is also important to consider the manner in which a decision is reached. This should be a balanced and systematic process founded on the principles of transparency and inclusive decision-making. Decisions about, which risk management option(s) are most appropriate for a particular site needs to be considered in a holistic manner. Key factors in decision making, illustrated in Figure 1, include:

- Driving forces for the remediation project;
- Risk management;
- Sustainable development;
- Stakeholders' views;
- Cost effectiveness
- Technical feasibility

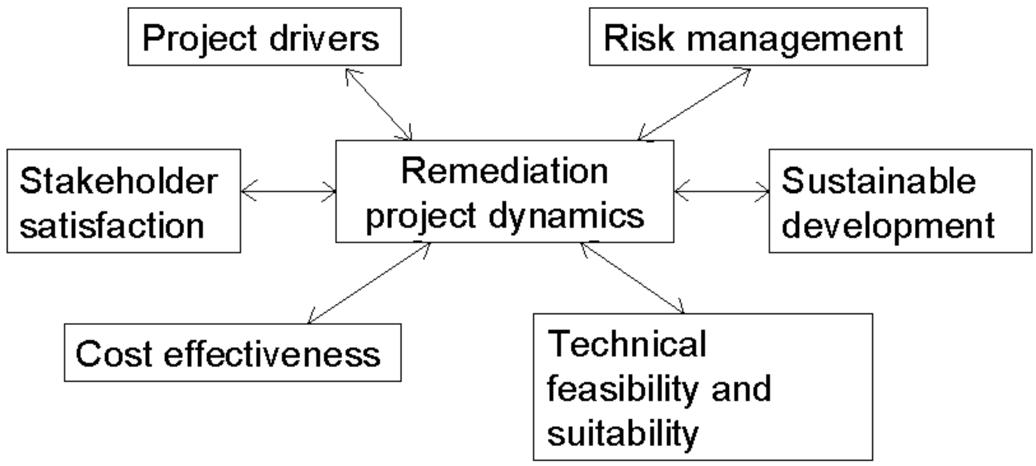

Figure 1. Dynamics for Technique Selection

1 Drivers and Goals for Remediation Work

Most remediation work has been initiated for one or more of the following reasons:

To protect human health and the environment. In most countries, legislation requires the remediation of land, which poses significant risks to human health or other receptors in the environment such as groundwater or surface water. The contamination could either be from "historic" contamination or recent spillage of substances from a process or during transport. Groundwater protection has in many countries become an important driver for remediation projects.
To enable redevelopment. Remediation of formerly used land may take place for strictly commercial reasons, or because economic instruments have been put in place to support the regeneration of a particular area or region; and/or
To limit potential liabilities., Remediation can take place as an investment to increase the potential value of land. Owners may perceive that a particular site could potentially have an environmental impact, which might leave them liable to third party actions in the future.

2 Risk Management

A risk-based approach has been adopted for the management of contaminated land in many countries (CLARINET and NICOLE, 1998, Ferguson and Kasamas, 1999). The assessment and management of land contamination risks involves three main components:

- The source of contamination (e.g. metal polluted soils, a leaking oil drum);
- The receptor (i.e. the entity that could be adversely affected by the contamination e.g. humans, groundwater, ecosystems etc.); and
- The pathway (the route by which a receptor could come into contact with the contaminating substances).

A *pollutant linkage* (see Figure 2) exists only when all three elements are in place. The probability that a pollutant linkage exists needs to be assessed. Risk assessment involves the characterisation of such a relationship, which typically includes: delineation of the source, measurement and modelling of fate and transport processes along the pathway, and assessment of the potential effect on and behaviour of the receptor. A consideration of risk must also take account of not only the existing situation but also the likelihood of any changes in the relationship into the future. From a risk management standpoint, remediation technologies are applied to the control of the source term and/or the management of contaminants along the pathway.

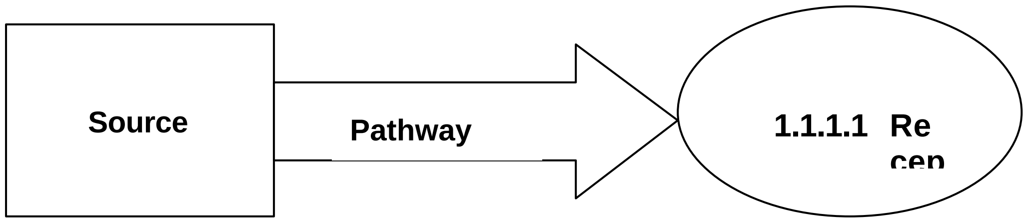

Figure 2, The pollutant linkage (including source, pathway and receptor) analysis needs to be addressed when considering the risk of a contaminated site. Remediation actions should be based on breaking significant linkages.

3 Sustainable Development

The concept of sustainable development gained international governmental recognition at the United Nation's Earth Summit conference in Rio de Janeiro in 1992. Sustainable development includes in the original concept: "…. *Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987). Underpinning all of these approaches are three basic elements to sustainable development: economic growth, environmental protection and social progress.

At a strategic level, the remediation of contaminated sites supports the goal of sustainable development by helping to conserve land as a resource, preventing the spread of pollution to air, soil and water, and reducing the pressure for development on greenfield sites. However, remediation activities themselves have their own environmental, social and economic impacts. On a project-by-project basis, the negative impacts of remediation should not exceed the benefits of the project.
Remediation objectives typically relate to environmental and health risks and perhaps performance of geotechnical / construction measures. These may form part of a larger regeneration project with social and economic aims, such as attracting inward investment. What is realisable, and the approaches that can be taken, will be subject to certain site/project specific boundaries, for example the time and money available for the remediation works, the nature of the contamination and ground conditions, the site location and many more. The objectives that can be realised by remediation works represent a compromise between desired environmental quality objectives and these site-specific boundaries. This compromise is reached by a decision making process involving several stakeholders. This decision making process is often protracted and costly, and can be said to represent the *core* of the remediation project. While achieving environmental quality objectives will normally underpin any

project dealing with contaminated land, desired quality objectives may be driven by a combination of technical criteria and third party non-technical perception of risk.

Remediation processes are used to achieve these core objectives. If the undesirable impacts of these remediation processes exceed the desired benefits of the core objectives, the core objectives may need to be re-evaluated. If proper risk management procedures have been followed, along with a thorough cost benefit analysis and stakeholder consultation, the risks of such a situation arising should be minimised, depending on the remediation approach selected.

Different remediation approaches will vary in their wider environmental impacts, as illustrated in Table 1; and perhaps also their wider social and economic effects (Table 2). For example, the acceptability to local residents of different processes can differ. It is therefore useful to consider the route taken to affect the remediation, as well as the core objectives of the remediation project. Assuming an overall "sustainability value" of the core objectives these "non-core" considerations help determine the remediation approach, which detracts least from this overall value.
At present there are no generally agreed means of carrying out sustainability appraisal for remediation projects. Although approaches to assessing the wider impacts of individual elements of sustainability (e.g. wider environmental effects) are under development in several countries, a truly integrated approach has yet to be found. There is some way to go before an international consensus can be reached in the way that agreement has emerged about the principles of risk assessment and risk management. This is hardly surprising given the complex interplay of economic, environmental and social factors that affect and are affected by a remediation project.

Table 1 Some Examples of the Wider Environmental Effects of Remediation Activities

Negative	Positive
Traffic Emissions (e.g. volatile organic compounds) Noise Dust Loss of soil function Use of material resources (e.g. aggregates) and energy Use of landfill resources	Restoration of landscape "value" Restoration of ecological functions Improvement of soil fertility (e.g. for some biological remediation techniques) Recycling of materials

Table 2 Examples of Wider Economic and Social Issues

Economic Consequences	Social Consequences
Impacts on local business and inward investment Impacts on local employment Occupancy of the site	Removal of blight Community concerns about remedial approach Amenity value of the site

4 Stakeholder Satisfaction

The stakeholders in remediation at the core of the decision making process are typically the site owner and/or polluter, the service provider and the regulator and planner. However, other stakeholders can also be influential, for example those listed below.

- Site users, workers, visitors,
- Financial community (banks, founders, lenders, insurers),
- Site neighbours (tenants, dwellers, visitors),
- Campaigning organisations and local pressure groups,
- Consultants, contractors, and possibly researchers.

Stakeholders will have their own perspective, priorities, concerns and ambitions regarding a site. The most appropriate remedial actions will offer a balance between meeting as many of their needs as possible, in particular risk management and achieving sustainable development, without unfairly disadvantaging any individual stakeholder. It is worth noting at this point that for some stakeholders, the end conditions of the site are likely to be significantly more important than the actual process used to arrive at that condition. Such actions are more likely to be selected where the decision-making process is open, balanced, and systematic. Given the range of stakeholder interests, agreement of project objectives and project constraints such as use of time, money and space, can be a time consuming and expensive process. Seeking consensus between the different stakeholders of a decision is important in helping to achieve sustainable development.

5 Costs and Benefits

Any good practice approach to the selection process for the remediation of contaminated sites needs to consider the costs and benefits attributable between different options. Many protocols have been developed, as decision support tools, to make such considerations, systematic, transparent and to a lesser or greater extent, reproducible. These have been discussed in more detail in the Final Report of CLARINET WG2 (*Bardos et al 2001*). Techniques employed fall into two broad categories:

- Multi-Criteria Analysis (MCA): A structured system for ranking alternatives and making selections and decisions, that incorporates selection of key variables to be compared, valuations for those variables, weightings for the valuations, and an algorithm for combining this data, and

- Cost Benefit Analysis (CBA): A form of economic analysis, also an MCA, in which costs and benefits are converted into monetary values for comparison.

Sometimes an intermediate approach is adopted in which the findings of an MCA are compiled as a numeric index, which is then divided by the projected remedaition costs of an option to provide a "cost effectiveness analysis".

Typically these analyses must consider a diverse range of impacts that not only vary from site to site but which may also differ from one proposed solution to another. In many instances, it is difficult to attach a strictly monetary value to many environmental effects, hence assessments - particularly of benefits, can involve a combination of qualitative, formal CBA and MCA methods. It is important to perform a sensitivity analysis to identify the most important cost driving factors, particularly where this encourages decision-makers to question their judgements and assumptions through the eyes of other stakeholders.

6 Technical Suitability and Feasibility

Remedial approaches can be categorised in a way that makes it easier to compare their suitability in general for particular problems, and their feasibility for more specific site circumstances.

A *suitable* technology is one that meets the technical and environmental criteria for dealing with a particular remediation problem. However, it is also possible that a proposed solution may appear suitable, but is still not considered *feasible*, because of concerns about:

- Previous performance of the technology in dealing with a particular risk management problem (in the countries);
- Ability to offer validated performance information from previous projects;
- Expertise of the purveyor;
- Ability to verify the effectiveness of the solution when it is applied;
- Confidence of stakeholders in the solution;
- Cost; and
- Acceptability of the solution to stakeholders who may have expressed preferences for a favoured solution or have different perceptions and expertise.

In general, concerns over feasibility tend to be greater for innovative remedial approaches, even if these have long standing track records in other countries. However, it is often these innovative solutions that are seen to offer more in terms of reducing wider environmental impacts and furthering the cause of sustainable development.

A suitable technique is one, which meets the technical and environmental criteria for dealing with a particular remediation problem. The choices that affect the suitability of a remediation technology for a particular situation are:

- Risk management application
- Treatable contaminants and materials
- Remedial approach
- Location
- Overall strategy
- Implementation of the approach
- Legacy.

These are outlined further in Table 3

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Acknowledgements

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Table 3 Factors Affecting the Suitability of a Particular Remediation Technology (Adapted from Nathanail et al 2001)

Risk management application	• *Source control,* remedial action either to remove, or modify the source of contamination • *Pathway control*; remediation to reduce the ability of a given contaminant source to pose a threat to receptors by inhibiting or controlling the pathway by modifying its characteristics • *(Receptor control*)
Treatable contaminants and materials	• Contaminant(s) • Concentration range • Phase distribution • Source and age • Bulk characteristics • (geochemistry, geology, microbiology)
Remedial approach	Type of remediation system (containment, treatment: biological, chemical etc) Each of which has its own particular strengths and weaknesses
Location	Where the action takes place (e.g.: *in situ* or *ex situ*, on site or off site);
Overall strategy	For example: • Integrated / combined approaches • Active versus passive measures • Long term / low input (”extensive”) versus short term / high input (”intensive”) • Use of institutional measures (such as planning controls combined with long term treatments)

<table>
<tr><td>Implementation</td><td>Implementation encompasses the processes of applying a remedial approach to a particular site and involves:
• Planning remedial operations
• Site management
• Verification of performance
• Monitoring process performance and environmental effects
• Public acceptability and neighbourhood relationships (risk communication and risk perception)
• Strategies for adaptation in response to changed or unexpected circumstances, - i.e. flexibility
• Aftercare

These activities are significantly different for different choices of remediation technique, and are likely to be a significant cost element for a remediation project</td></tr>
<tr><td>Outcome</td><td>Destruction may be result of a complete biological and/or physico-chemical degradation of compounds, for example at elevated temperatures by thermal treatments.

Extraction of contaminants may be brought about by (a) excavation and removal (b) some process of mobilisation and recapture or (c) some process of concentration and recovery. Recycling might be the "ultimate" form of removal.

Stabilisation describes where a contaminant remains in situ but is rendered less mobile and or less toxic by some combination of biological, chemical or physical processes.

Containment where the contaminated matrix is contained in a way, which prevents exposure of the surrounding environment.

• Destruction may be incomplete, emissions and wastes are an outcome of all approaches, hence consideration of the fate of compound should be included as part of both remedy selection AND evaluation of risk management.
• Extraction implies a need for further treatment and/or subsequent disposal
• Stabilisation and containment both leave contamination in situ, which means that their performance in the long term requires thorough assessment</td></tr>
</table>

PART 2: CASE STUDY EXAMPLES OF SUSTAINABILITY APPRAISAL FOR REMEDIATION PROJECTS

7.3 SUSTAINABILITY: THE ENVIRONMENTAL ELEMENT – CASE STUDY 1

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Abstract

At the former Norwegian main airport approximately 40 sites have to be remediated at the 3,4 km^2 site. This involves excavation of 150.-350.000 m^3 soil, of which more than 50.000 m^3 is contaminated and has to be treated. Statsbygg has used a method developed to incorporate the overall potential environmental effects in the evaluation of different remedial options, together with economy, time and technical functionality. The testing of the method involved environmental assessment, and demonstrated how environmental costs and benefits for different remediation techniques can be calculated and incorporated in the assessment of the entire remediation project.

Introduction

The former Norwegian main airport (at Fornebu) will become a residential and commercial area with large green areas and nature reserves. The overall target for the clean up at Fornebu is to remove sources of contamination that represent an environmental threat or conflict with the future use of the area.

Statsbygg is responsible to carry out remedial measures at the contaminated sites. Local environmental targets have been drawn up and site-specific risk assessments will clarify the need for remediation at each site.

Excavated soil that is biological treated will be used for landscaping in accordance with the overall plan for soil management. Reuse of treated soil (together with asphalt and concrete) is one of the main environmental targets for the development of the Fornebu area.

Another goal for the development project is to incorporate overall environmental impacts as parameters for decision and accounting. The methodology is to incorporate the environmental costs and the anticipated environmental benefits of the remediation project (environmental assessment) in the decision process together with function, economy and time.

Statsbygg has used a model developed by the by Danish National Railway Agency and the Danish State Railways as a supporting tool when deciding between alternative remedial options at a contaminated site.

Method for Environmental Assessment in the Decision Process

The basis for the environmental assessment is to estimate the positive environmental effects in relation to the financial costs and the negative environmental effects. The environmental costs involve the work processes throughout the life cycle of the remediation. The work processes includes the consumption of materials, fuel and energy consumption (discharges to air, soil and water) and effects on human beings (including noise an odour related annoyances).

The model then calculates the potential environmental effects presented as:

- ✓ The absolute consumption of resources and potential environmental effects in respective units.
- ✓ Normalised consumption of resources and potential environmental effects stated in human equivalents.
- ✓ Weighted consumption of resources in relation to the horizon of supply and weighted potential environmental effects based on the society's targeted reduction goals of discharges to the environment. The results of the calculation of the effects can be presented in diagrams for the most significant and most common effect types.

Description of the Site and Remedial Options

The actual site was an oil-contaminated site covering an area of 7.400 m^2. Both the soil and the groundwater were contaminated at a depth of 3,5-5,0 m below surface. At the ground water level free phase oil was found in some areas. The main sources of contamination was leaking storage tanks for diesel and heating oil and former infiltration of run-off water.

The remedial options were either traditional excavation and biological treatment at a local treatment facility, or biosparging to stimulate the in situ bio-degradation of the oil compounds. The remediation also included removal of 6 tanks, were at least one of the tanks had been leaking.

The costs of the remedial options were of the same magnitude for the two solutions. The time frame of remediation was a 4-year period, not excluding the biosparging alternative. Today's use of the area is parking and storage facilities, and the future use is housing and park areas. If excavation was chosen, the excavated volume had to be filled with other soil from the area and the environmental effects of this work had also to be accounted for.

The environmental benefits of both remedial options were equal, and were therefore not included in the assessment. Removal of free oil was necessary in both cases, and was also not included in the comparative assessment.

Results of the Environmental Assessment

The energy consumption of the excavation alternative is 5 times that of the biosparging alternative. The fuel consumption during excavation, treatment and filling of 37.500 m^3 is calculated to 53.000 litres of diesel, and 9.000 litres during biological treatment of 4.500 m^3 oil contaminated soil.

The emissions of greenhouse gasses connected to the excavation alternative are 3 times that of the biosparging alternative. Emissions of CO_2 during the excavation alternative is calculated to a total of 170 tonnes.

Consumption of electricity is responsible for most of the environmental costs of the biosparging alternative. It should be noted that in Norway hydropower plants supply most of the electricity, with almost no CO_2 emissions. In other European countries this will often not bee the case, as electricity can be supplied by nuclear power plants or coal fired plants.

The use of metallic materials is of equal magnitude, but the distribution of the different metals is not equal. Iron and manganese are used most in the excavation alternative due to fabrication of machines. Nickel and copper are the most used metals in the biosparging alternative due to pipes for injection of air and electrical equipment.

The waste amount is 35 % greater with the biosparging alternative because of all the compounds included in the remediation equipment.

Conclusions

Based on the environmental assessment, together with the reduced physical impact Statsbygg selected biosparging as the remediation alternative.

Statsbygg has gained useful experience from this environmental assessment and will perform equal environmental assessment for future remediation projects, both for remediation of contaminated soil and for handling and reuse of soil from excavation and demolition work.

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7.4 SUSTAINABILITY: THE ECONOMIC AND SOCIAL ELEMENTS – CASE STUDY 2

GROUNDWORK'S 'CHANGING PLACE' PROGRAMME – A CASE STUDY OF A COMMUNITY LED APPROACH TO REMEDIATION OF BROWNFIELD LAND

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Abstract

For the last twenty to thirty years a considerable sum has been spent by the public and private sector in the process of reclaiming this land. The focus, has in the main, been on hard end uses – commercial and industrial development and housing. This paper outlines how the UK organisation Groundwork manages the social and economic dimensions of brownfields remediation, particularly considering the aspirations of local communities. The reclamation process has been largely the domain of civil engineers. Driven largely by political necessity – that is the necessity to replace lost jobs – the prevailing sentiment has been that of economic development. Is this focus alone either equitable or sustainable as we enter the new Millennium?

1. The Groundwork Organisation

Groundwork is a large environmental charity whose operational area covers England, Wales and Northern Ireland. The Groundwork approach is to develop programmes that link environmental, social and economic regeneration and to contribute to sustainable development.

In order to fit the Groundwork approach to regeneration programmes into its correct context it is first necessary to understand something of the nature and working of the Groundwork organisation.

1.1 Key themes

The Groundwork logo is the green triangle which is used to represent the way in which Groundwork conducts its operations based on three key themes:

- Physical environmental improvements
- Educating and involving the community
- Integrating the economy and the environment

1.2 A joined up approach

The green triangle serves as a very useful metaphor in another important respect, for just as there can be no such thing as triangle without three sides then Groundwork's work must always have the above key components. These together form the basis of a holistic approach to regeneration

1.3 Physical Environmental Improvements

A great deal of Groundwork's work involves delivering improvements to the environment through the removal of dereliction. It was as a result of engaging with the issues relating to derelict land reclamation that Groundwork, in 1995, commissioned a study to look at the array of problems relating to this particular social blight. The result was the *'Post Industrial Landscape' Report* prepared by Professor John Handley at the University of Manchester. This report played a vital role in Groundwork's operations in the latter half of the decade and was later to form the foundation upon which the Groundwork Changing Places Programme was built.

1.4 The 'Post Industrial Landscape' – A Groundwork Status Report 1995

The report highlighted several key issues. The first of these was that the stock of derelict land in England and Wales had been constant for over two decades

Whilst the amount of dereliction had remained constant at around 35,000 ha, the study found that this was not due to a disregard for the problem. On the contrary, the government funded land regeneration agencies had been promoting the reclamation of derelict land at a significant rate. So why was the stock remaining so obdurate to change?

The answer was that the stock of dereliction was being added to at almost the same rate at which it was being reclaimed. In fact the net gain over two decades had been just 900 hectares and the report concluded that, at such a marginal rate, it would take over 200 years before the problem of derelict land could be eradicated.

Whilst the study concentrated largely on derelict land because the narrowness of this definition facilitated the accumulation of statistical data, it should be said that the general observations of the report apply equally to what has since come to be known as Brownfield land.

The way in which brownfield land acts as a blight, reducing a community's quality of life as well as its sense of self esteem was also studied. As part of the report a MORI poll was conducted. Whilst confirming that peoples' primary concerns often centred on employment, health and education, the survey went on to indicate that the environment within which communities lived was also of great interest and that 71% of people sampled believed that brownfield land reduced the quality of life. It was also confirmed that 75% were of the opinion that local people should be involved in determining the ways in which their local landscape should be developed.

These issues highlighted the need for innovative changes in the methods employed when dealing with the problem of derelict land. Professor John Handley aptly summed up the situation in these words:

"*Derelict land is not just a technical problem – there is also an important human dimension. The time has come to ensure that resources committed to land reclamation produce the best results – AND THAT PEOPLE IN THE COMMUNITIES AROUND THEM ARE*

***INVOLVED IN MAKING THE SOLUTION A REALITY AND MAINTAINING THE CHANGE IN THE FUTURE*.”**

In 1995 these sentiments crystallised into a submission to the Millennium Commission for a large scale, ecologically informed and community led programme of land regeneration. The programme was given the name ‘Changing Places’.

2. The ‘Changing Places’ Programme

The Groundwork ‘Changing Places’ Programme is the result of a successful Round 1 bid to the Millennium Commission in 1995.

‘Changing Places’ is comprised of 21 individual sites with a cumulative area of over 1000 hectares. The sites are being delivered by individual Groundwork Trusts and are distributed throughout England and Wales. The total programme value is a little over £55 million with £22.1 million of this amount being funded by the Millennium Commission.

The aim of ‘Changing Places’ is:

> ***“To transform land which has a negative impact on local communities into new, positive assets and to celebrate this renewal at the beginning of a new millennium.”***

2.1 Typical ‘Changing Places’ Projects

All the sites in the programme arise from the effects of the first industrial revolution which created wealth and employment based on primary industries such as coal mining, chemical production, steel-making and supporting infrastructures. It is not surprising therefore that the list of typical sites includes:

- Abandoned collieries.
- Old landfill sites – themselves emanating from previous extractive processes.
- Redundant chemical works.
- Disused quarries and gravel workings
- Canals

Because of the past symbiotic link between the location of industries and the concentration of those human settlements that grew to provide labour, ‘Changing Places’ sites sit ‘cheek by jowl’ with areas of dense human habitation. It has been calculated that as many as 2 million people live within 15 minutes travel time to a ‘Changing Places’ project. This means that the sites will operate as vital ‘green lungs’ for communities wishing to enjoy their local environment.

2.2 Examples of Project Schemes

The type of project being funded includes:

- A community nature area at a worked out gravel pit.
- Community parks with a strong emphasis on nature conservation and environmental education.

- Angling and environmental studies facilities on a former chemical works.
- A community regeneration scheme based on creating an international indoor climbing facility with additional tourist orientated facilities on adjacent reclaimed colliery areas.
- A community park with a riding centre for disabled people utilising restored hospital buildings dating back to the last century.

3. The 'Changing Places' Approach

The programme has been designed to fulfil the criteria set out in the 'Post Industrial Landscape' report by ensuring that all projects, where possible:

- Involve the community
- Are delivered in an ecologically informed manner
- Are capable of enduring

3.1 A Community Led Approach

It is quite fashionable these days for people involved with brownfields regeneration to infer that they have consulted with the community when what they truly mean is that they have encouraged a potential brownfields developer to have talks with the Local Authority. This is not what is meant when community participation is referred to within the 'Changing Places' programme. A set of exhibition boards covered in drawings showing the designers proposals constitutes little more than tokenism.

In 'Changing Places' the individual communities served are fully involved in the processes of design and delivery and a constant dialogue is maintained through the use of consultation exercises and the establishment of community groups.

Once the community has been given the opportunity to engage with the project it is vital that the proper follow-through occurs. This means ensuring that the designers work with local people to finalise design detail and that, through steering groups and local meetings, people are kept in charge of the information.

One important consequence of this approach is that communities, once they feel integrated into a project will often display a mature attitude to risk that opens the way to projects designed on a 'fit for the purpose' basis.

3.2 An ecologically informed approach

The reclamation of the 'Changing Places' sites is ecologically informed – enhancing natural regeneration wherever possible and capitalising on the low levels of fertility often to be found in the soils of damaged sites. This method of 'working with nature' often leads to lower cost solutions and increases biodiversity whilst, at the same time laying down an excellent foundation for future sustainability.

Berry Hill Fields project in the heart of the city of Stoke-on-Trent is one example. The landscape is comprised of open grassland that has naturally recovered from an earlier use for coal mining. Nature, by and large still the most effective reclaimer of land when the correct conditions prevail, has produced a habitat that supports a large bird population. A visitor to the site in the early summer will be treated to the song of the skylark – a bird in sharp decline in the country due to modern farming techniques. The reduced fertility has suppressed the more competitive species allowing plants such as the common spotted orchid to re-colonise areas - and all this is being celebrated by an ever appreciative community who greatly enjoy the facility of a 'green lung' in the midst of high density social housing.

4.0 Beyond Brownfields – Today's Problems

That Brownfield land damages people's lives is not disputed. Brownfield land, often represents a double abuse to communities. Firstly, there is the loss of jobs but secondly there is the visual and social abuse that derelict land heaps on the communities that have been left behind. Unsightly land is a magnet for a wide array of unsociable activities from fly tipping to crime. It reduces a community's self esteem by being a constant reminder that they are no longer needed. It can be unsafe but at the same time a lure for children desperately seeking a landscape within which to play. It can be the source of pollution that slowly poisons the environment.

That large numbers of people are affected is not accidental. At the dawn of the Industrial Revolution a vast world of apparently limitless resources appeared to be there for the taking. Industries were established where there existed the necessary amalgam of natural resources. Urban development continued at a pace until the first Industrial Revolution came to a halt in the closing decades of the 20th Century. At this point many developed countries saw a rapid rise in unemployment and a sharp rise in the stock of brownfields land. In very broad terms the reasons for this were an increasing expansion of technology leading to the globalisation of markets in conjunction with a rising population in the developing world.

In the UK these factors, stimulated the programme of regenerating brownfields land. For the last twenty to thirty years a considerable sum has been spent by the public and private sector in the process of reclaiming this land. The focus, has in the main, been on hard end uses – commercial and industrial development and housing.

The reclamation process has been the domain of civil engineers. Driven largely by political necessity – that is the necessity to replace lost jobs – the prevailing sentiment has been that of economic development.

Whilst economic development is still required – especially in those pockets of persistent depravation - at the start of the 21st Millennium we have to ask ourselves whether we can assume that a narrow focus based around economic development is still valid with regard to brownfields land. At the threshold of the new era, on a global scale, is such thinking either equitable or sustainable?

5.0 Beyond Brownfields – Towards an Equitable and Sustainable Development

In the closing phase of the first industrial revolution a male worker might well have left school at the age of fourteen or fifteen. He would have expected to work for some forty or fifty years, if not for the same employer, then certainly in the same industry and within the same locality. He would have married and raised a family and lived within a relatively close proximity to his work. He was intimately associated with place through his work.

Post-industrial workers will experience a totally different world. It will be a world of rapid, global, economic and technological change. What this all means is that the logical link between where people live and where they work will, in many cases, and for the first time in the history of mankind, be severed for good. These changes in industry and commerce will change our needs for hard end uses for brownfields developments.

It is certain that these changes will impact on decisions relating to brownfields. In a world in which over 70 multi-national companies have revenues larger than the GNP of Cuba we are obliged to face the fact that governments are becoming increasingly impotent in matters relating to investment and employment. Corporate interests will always optimise on profitability and global corporate forces will decide the fate of brownfield development. This will mean that an increasing amount of development will take place in the third world leaving a growing stock of post-industrial land in the countries that saw the birth of the first industrial revolution.

This is not to say that countries of the developed world will be economically poorer. On the contrary, the USA and The UK are enjoying strong economic growth - with the lowest national unemployment levels for decades. But modern industry needs less land and employs fewer people in order to generate the same profit as twenty years ago. Furthermore, the new economic growth is knowledge based which in turn aggravates the problem of the polarisation of societies.

Another global engine driving change at an increasing rate is that of population growth. By the year 2020 it is predicted that the combined populations of Asia and Africa will equal the total current global population. Again, from an economic perspective these statistics are not necessarily bad news for the developed countries that will enjoy the benefits of growing markets. But it will mean that, for developed countries, the demand for industrial sites will not return to the levels of the first industrial revolution. Heavy industry and commerce will be located where labour is cheapest. This will be within the boundaries of the developing countries of Africa and Asia whose inhabitants aspire ever more to enjoy the benefits that the developed countries have had for a considerable time. As a part of their quest for a higher standard of living, these people will be willing to work at much lower levels of remuneration and hence will be employed by global corporations working across national boundaries.

Faced with these pressures the question facing developed post-industrial societies will be - what should be done with the land? Doing nothing is not a satisfactory option for those communities that sit adjacent to urban blight. Using brownfield land for housing and for commercial development is beneficial where the market is strong enough to make such development viable. But if the above observations are accurate, it will mean that an increasing stock of brownfields land will remain vacant or derelict.

In such circumstances turning the residual quantity of brownfields land into a green amenity land may well be the best sustainable solution.

If this strategy were to be adopted, at the very least, the communities living adjacent to these areas would receive substantial visual and amenity benefit. Established green amenity land would also improve an area's general image thereby increasing the chance of attracting commercial investment in a very competitive market. And finally, the environment would certainly be a major beneficiary as a result of the increase in bio-diversity.

7.5 SUSTAINABILITY: INTEGRATED ASSESSMENTS – CASE STUDY 3

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Abstract

A risk-based approach to contaminated land management has been promoted by the CARACAS community, and has been adopted in many European countries. Clean-up operations, however have costs and benefits. Clean-up operations require the use of resources (such as energy and clean water), and may lead to a transfer of contamination to other compartments (due to air or water emissions). Development of sustainable clean-up operations, therefore, are a matter of balancing the full range of environmental and financial costs and benefits. This balancing of the pros and cons has been one of the objectives of the CLARINET community. Within the scope of CABERNET our balancing skills will have to evolve into nothing less than an art: not only ecological and economical qualities, but also social qualities will be important in brownfield redevelopment projects. On the one hand, to prepare for the CABERNET era we will have to learn to look over the horizon. On the other hand, we can make use of the general patterns in decision making we already know from the CLARINET era.

1. Introduction

1.1. Decision Making Processes

Arriving at an optimal risk management solution for a contaminated site (Bardos and Vik, 2001), or at a sustainable clean-up alternative (Okx, 1998), or at the best brownfield development alternative involves a decision process. A general model for decision processes (Figure 1) is given in Mintzberg et al. (1976). The seven central routines in the figure can be linked to the three main phases of decision-making: problem **identification**, **development** of problem solving alternatives and **selection** of the best alternative. The **identification** phase consists of the central routines: *recognition*, in which the problem is recognised and evokes decisional activity and *diagnosis*, in which the decision makers seek to comprehend the evoking stimuli and determine the cause-effect relations for the decision situation. The **development** phase contains a *search* routine to find ready-made solutions and a *design* routine to develop tailor-made solutions. The **selection** phase contains a *screen* routine to reduce the number of generated ready-made solutions, an *evaluation/choice* routine, which operates in three different modes - judgement, bargaining and analysis - and an *authorisation* routine to obtain approval. The phases and routines can easily be identified in most guidelines for contaminated soil (Gotoh and Udoguchi, 1993; Dreschmann, 1992), moreover, they are applicable to all our decisions.

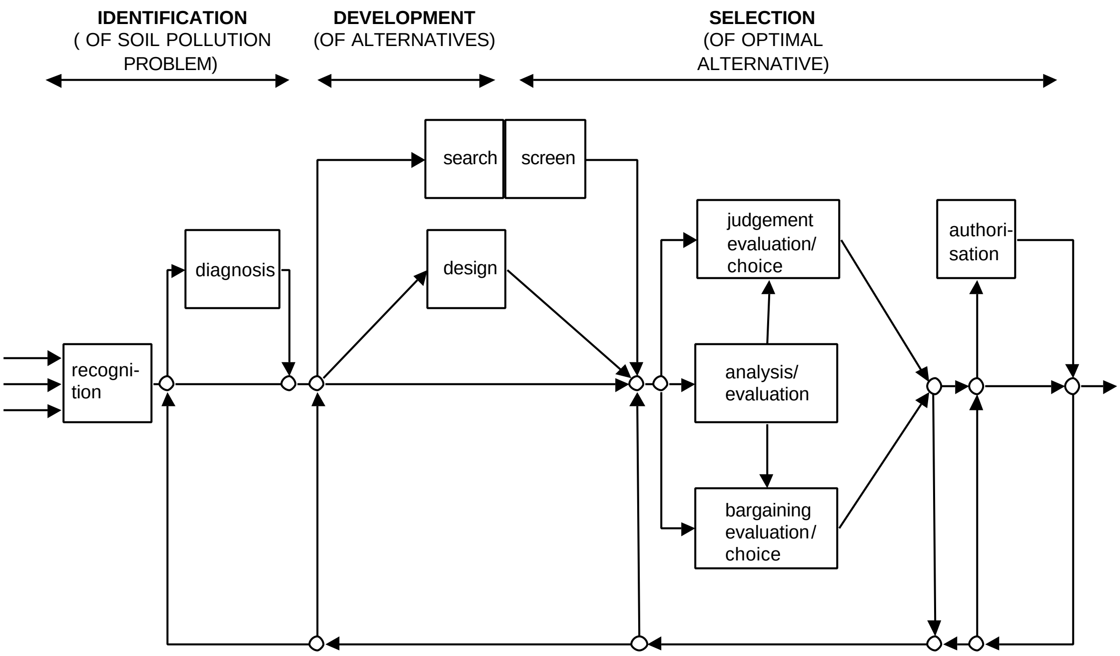


Figure 1. A general model for decision processes (Mintzberg et al., 1976)

Interrupts may occur in the process, originating from the decision environment, and can delay, accelerate, stop or restart the decision process. Internal and external interrupts are common in soil remediation and are related to the need and nature of the strategic decision respectively. New option interrupts are less common, but may occur in cases of considerable timelag between authorisation and the final realisation of a project.

1.2. The Multiobjective Setting

The majority of decision situations share important similarities. First, decision-makers evaluate a set of **alternatives**, which represent the possible choices. The **objectives** to be achieved drive the design (or screening) of alternatives and determine their overall evaluation. **Attributes** are the measurement rods for the objectives and specify the degree to which each remedial alternative matches the objectives. Finally, **factual** information and **value** judgements jointly establish the overall merits of each option and highlight the best compromise solution (Beinat, 1997). Figure 2 summarises the information that plays a role in a multiattribute model. The information items are the multiattribute profiles ($A_1,..,A_m$) allowing measurement of the achievements of the (remedial) alternatives, the value functions (v_i , $i=1,..,n$) representing human judgements, the weights (w_i , $i=1,..,n$), and the multiattribute value function that associates an overall value with each alternative ($v(A_j)$, $j=1,..,n$). In this example, the overall merit of a decision alternative is computed as a weighted sum of single-attribute performances regarding all attributes. Although this evaluation scheme is very common and widely used, it is important to stress that it can be applied only under very precise conditions. Without going into this topic (see Beinat 1997 for an overview), it is sufficient to say that the additive rule can be applied only if independence conditions across attributes are met. This, in turn, calls for a careful structuring of the decision problems and a careful choice of the attributes.

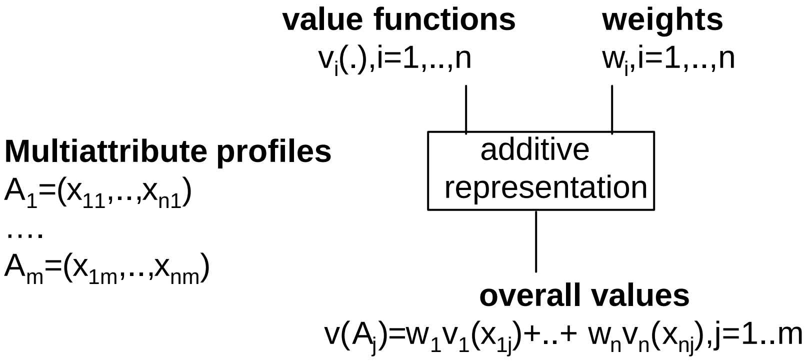


Figure 2. Information items in a multiattribute model (Beinat, 1997)

2. The Clarinet Era: Sustainable Remediation

Bardos and Vik (2001) argue that the key factors in decision making on remediation technologies are:

- driving forces for the remediation project;
- risk management;
- sustainable development;
- stakeholders views;
- cost effectiveness and
- technological feasibility.

REC (Okx, 1998) is an exponent of similar thinking, it produces three indices for each clean-up alternative: Risk reduction, Environmental merit and Costs. Together, these indices summarise the overall performances of each option.
Figure 3 shows an example of the REC results for three remedial options for a polluted site. The MF option (multifunctional option: soil excavation and groundwater extraction) provides high risk reduction and environmental merit at high costs. The ICM option (Isolation and Control Management) has a much inferior risk reduction, a negative environmental merit balance, but is the cheapest option. The In Situ option (biological remediation) provides high risk reduction, intermediate environmental merit performances at rather low costs.
The selection of a remedial alternative is a multipurpose problem. Ideally, the alternative selected is that which maximises risk reduction and environmental merit and minimises costs. However, in practice such an alternative is rare, and therefore the final selection is usually based on weighing the advantages and disadvantages of each remedial alternative.
The REC methodology yields the information required for such a weighing. The indices for R, E and C:

indicate the main consequences of remedial operations in a simple, direct manner;

introduce a structure to the decision-making process;

clarify the situation for the decision-makers and therefore make it easier for them to decide.

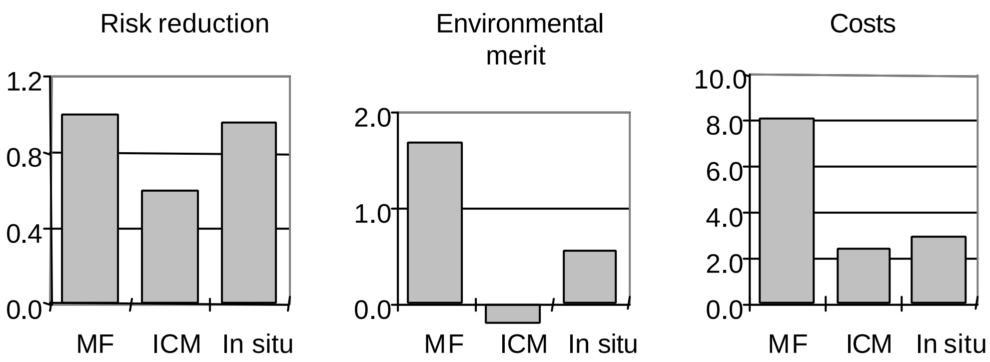


Figure 3 The indices for R̃, E (both dimensionless) and C (in millions of guilders) in the example case.

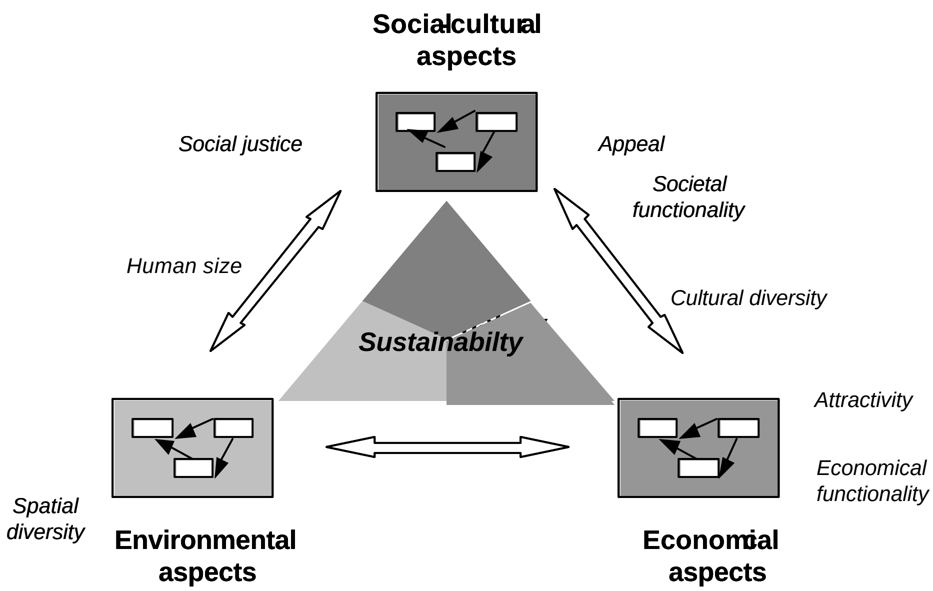
The final quality of the remedial alternative in a certain decision context is a function of the R, E and C indices as well as other factors not associated with the REC methodology. This function may either be determined explicitly or will implicitly play a role in the consultations held between actors.

3. The Cabernet Era: Sustainable Development

Decision making on the redevelopment of brownfields should address the following key factors:

- driving forces for the redevelopment project;
- risk management;
- sustainable development;
- stakeholders views;
- cost effectiveness and
- feasibility.

Figure 4. The three dimensional nature of brownfield redevelopment



Thus, basically the same factors as those mentioned by Vik and Bardos (2001) for remediation projects. These factors should be expressed as measurable qualities.

What exactly do we want to achieve? As a result of a first scoping exercise we would like to present the three dimensional nature of the problem (Figure 4).
Allthough we are able to point out the three dimensional nature of brownfield redevelopment it is still a long way to operationalisation of these aspects.
Operationalising the social-cultural aspects is – given our background -probably the hardest to do. We will have to collaborate with experts from other disciplines. However, we should pay attention to the following trends in our society:

- demands for responsible management: welfare, use of resources and investments should be balanced;
- clients do care more and more about image and they want transparancy in the activities of organisations;
- clients do want sustainable and affordable products and projects.

Operationalising the environmental aspects will be – since it is near to our core business - relatively easy. The “DG XI Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions” and CHAINET “Analytical tools for environmental design and management in a systems perspective” (Wrisberg, 2000) provide us a wide scope of analytical tools such as Environmental Impact Assessment, Life Cycle Assessment, Cost benefit Analysis, Cumulative Energy Requirement Analysis, Material Flow Accounting and so on. No need to do the job all over again.
Projects without economical quality will not survive, and thus are not sustainable by definition. Simple calculations on remedial costs will not enough to base our decisions upon, and financial forecasting will be necessary. Whatever the business case, there are corresponding financial risks relating to a developer’s ability to meets its corporate and project objectives (Finnamore, 2000). We need to make these risks explicit.
The social-cultural quality, the environmental quality and the economical quality have to be balanced. The selection of a development is again a multipurpose problem. Ideally, the alternative selected is that which maximises social-cultural quality, environmental quality and economical quality. However, also in this case such alternatives are rare, and therefore the final selection is usually based on weighing the advantages and disadvantages of each alternative. To assess the value of a brownfield redevelopment alternative we need a methodology yielding the information required. It has to:

- indicate the main consequences of remedial operations in a simple, direct manner;
- introduce a structure to the decision-making process;
- clarify the situation for the decision-makers and therefore make it easier for them to decide.

In our point of view such a methodology can be derived from earlier experiences such as the REC methodology.

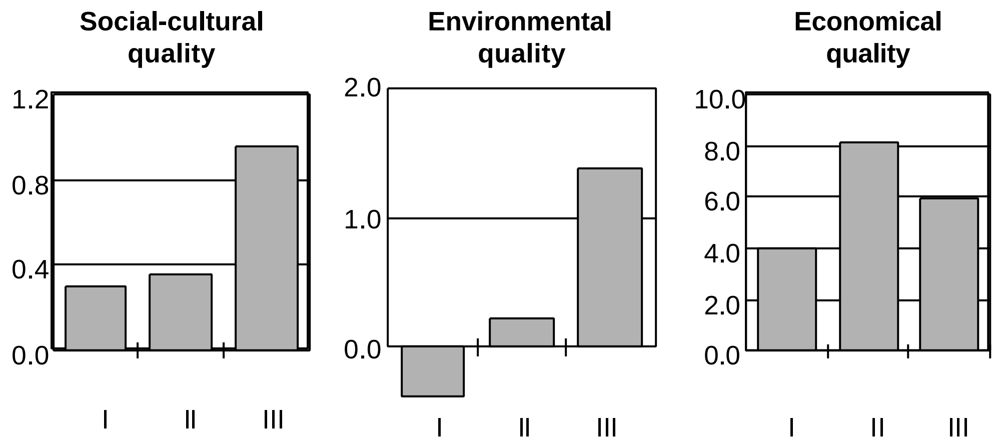


Figure 5 The indices for social-cultural, environmental, economical quality.

Conclusions

The general pattern of decision making, such as described by Mintzberg at al. (1976), provides with a framework which is:

- directly applicable to virtually all decision making processes;
- suitable to study problems that include aspects derived from any number of different disciplines and specialisations.

Brownfield redevelopment operations, however have costs and benefits. Redevelopment of sustainable redevelopment, therefore, are a matter of balancing the full range of social-cultural, environmental and economical costs and benefits. To prepare for the CABERNET era we will have to learn to look over the horizon, that is we need to co-operate with scientists from social and economical disciplines. However, we can make use of the general patterns in decision making we already know from experiences from the CLARINET era.

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